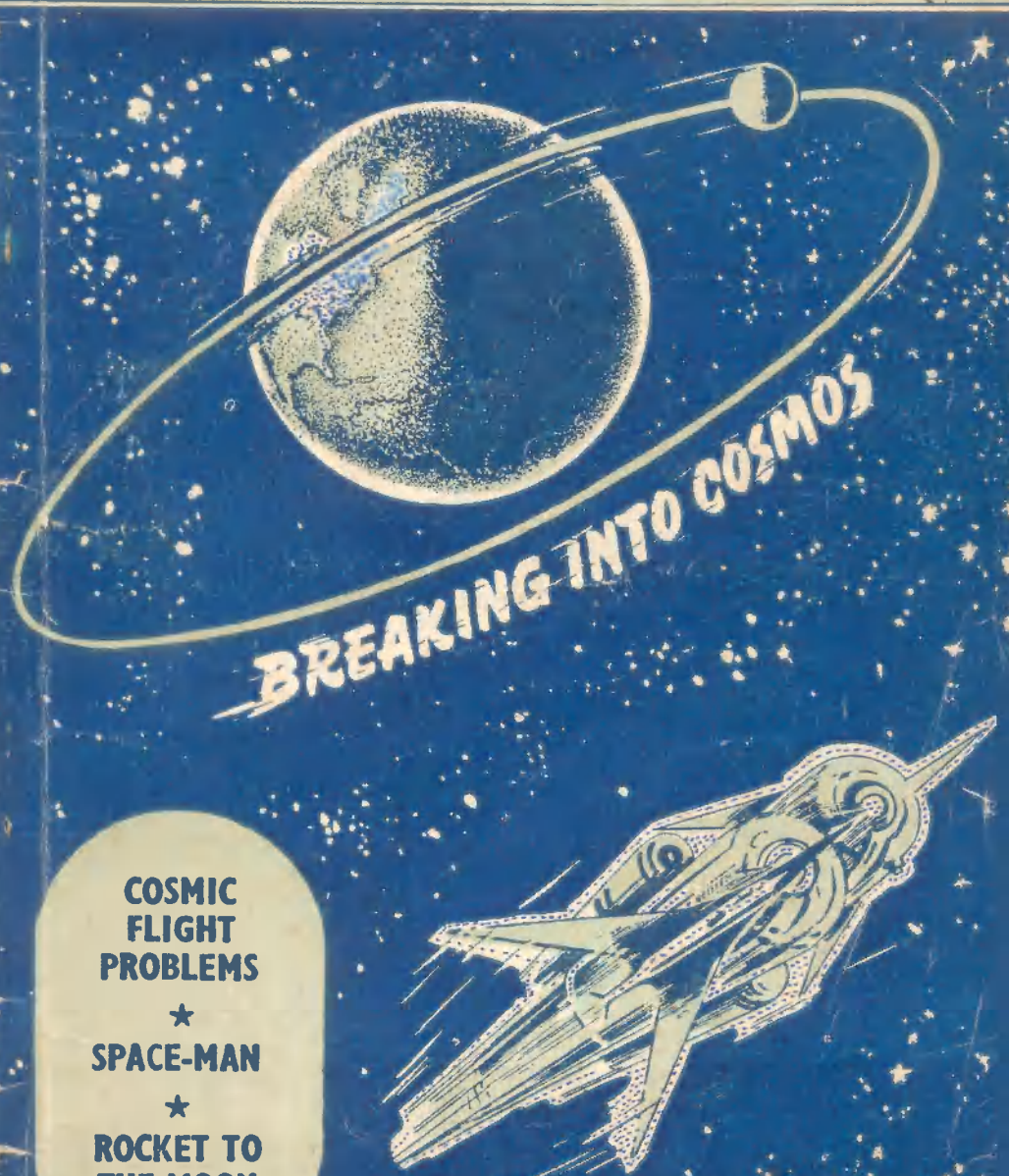
SPUTNIKS



COSMIC FLIGHT PROBLEMS

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SPACE-MAN

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ROCKET TO THE MOON

SPUTNIKS

Breaking into Cosmos

THE INFORMATION DEPARTMENT OF THE
USSR EMBASSY IN INDIA, NEW DELHI.

First Edition : December 1957.

Second Edition : February 1958.

Edited by G. Efimov, and Published by N. K. Dorodnitsyn for the Information Deptt. of the USSR Embassy in India, 25, Barakhamba Road, New Delhi and Printed by D. P. Sinha at New Age Printing Press, 5, Jhandewallan Estate, M. M. Road, New Delhi.

"....Apparently our contemporaries are destined to see mankind's most daring dreams come true"....

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Sputnik No. I

The whole of humanity admires the great scientific feat of the Soviet people who have produced the world's first man-made Earth satellite. A new era in the history of the development of science and engineering started on October 4, 1957, the day when the satellite was launched.

The great interest displayed towards everything concerning the satellite is understandable. What is its design? How was it put up to such height? How long will it be circling the Earth? What data needed for science are we receiving from it? These are but a few questions which agitate entire progressive mankind.

The Satellite's Design

The satellite is spherical in form with a diameter of 58 cm. It weighs 83.6 kg. The body of the satellite is made of aluminium alloys and its polished surface has been specially treated. Inside the body are various instruments as well as the power resources for the apparatuses, in particular, for the two radio transmitters which continuously emit signals received at a distance of up to 10,000 km. On the outer surface of the body four aerials in the form of rods 2.4 to 2.9 metres long are installed.

During the flight, the satellite is subjected to sharp heating and cooling. Soviet scientists had to elaborate many problems in order that the satellite's design ensure normal temperature conditions for the work of the apparatus over a long period. This is achieved by the proper selection of materials, distribution of instruments, as well as the circulation of gaseous nitrogen with which the satellite was filled before its launching.

How the Satellite Was Placed in Its Orbit

The problem always arose before people who dreamed of penetrating beyond the Earth's atmosphere—what means are needed to attain this? K. E. Tsiolkovsky, the outstanding Russian

scientist, solved this problem. He showed that a rocket was the means for space flight.

The carrier-rocket used for launching the first satellite is an intricate device. It has powerful engines, working at various temperatures and at low air densities and capable of driving the rocket up to an altitude of a thousand kilometres. Soviet scientists very accurately elaborated a system of steering the rocket.

DRAWING OF THE THREE-STAGE ROCKET

The first stage —

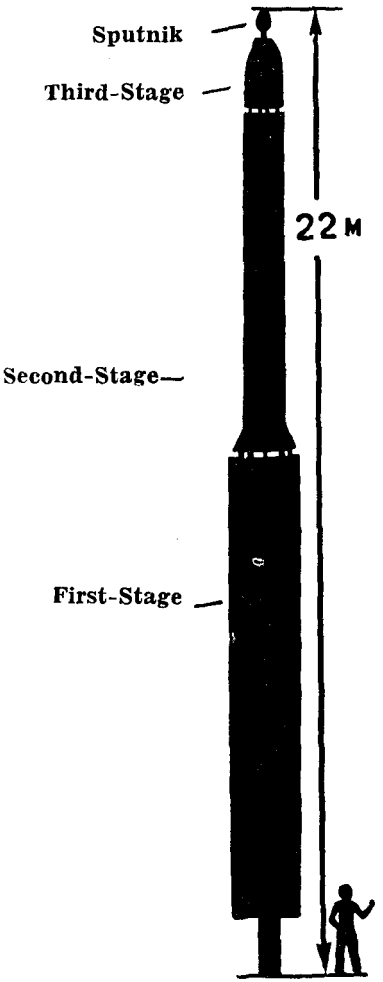
a guided rocket launches the whole missile to a precalculated height and imparts 15 per cent of the required orbital speed of the satellite.

The second stage —

a rocket with a liquid fuel engine provides for attaining the next height stage, and imparts 32 per cent of the satellite's orbital speed.

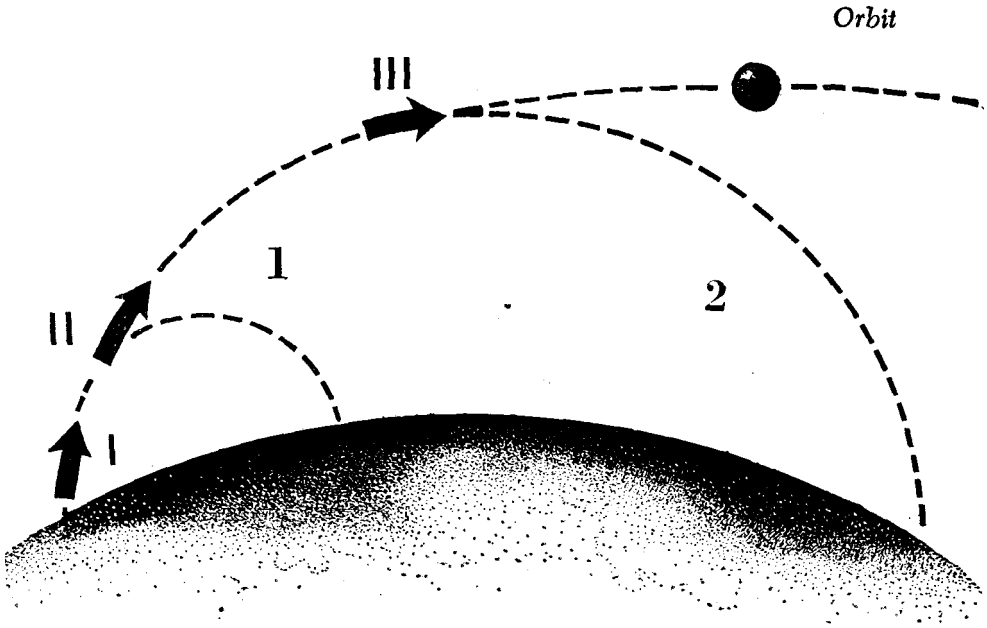
The third stage —

a rocket with a hard fuel engine. The satellite is placed in its nose and is separated when the required orbital speed is attained.



The satellite was placed in the nose of the carrier-rocket and sealed behind a protective cone. The other part of the rocket was filled with fuel and various control instruments.

The rocket was launched vertically. Then, with the help of a special device, the rocket's axis gradually started to curve away from the vertical course. At an altitude of several hundred kilometres the rocket started to move parallel to the Earth at a speed of 8,000 metres per second.



Launching trajectory of the satellite with a three stage rocket
1. *Fall of First Stage Rocket*
2. *Fall of Second Stage Rocket*

When the engine stopped working the protective cone was automatically dropped away and the satellite separated from the rocket and started out independently. Three unusual bodies appeared in space, the spheric satellite, the carrier-rocket and the protective cone. At first they moved at a small

distance from each other, then they parted. This is mainly explained by the fact that all the three bodies experience different resistance in the upper atmosphere.

The Satellite's Orbit

The orbit of the satellite is an ellipse. Its lower point at present is in the northern hemisphere, and its highest in the southern. The plane of the satellite's orbit crosses the globe approximately from south-west to north-east.

The plane of the orbit remains almost constant as regards the stars. However, the Earth rotates around its axis from west to east. This rotation takes place, as it were, in a circle formed by the orbit of the satellite. Therefore, with each new revolution around the Earth, the satellite passes over various regions of our planet. With each new loop the satellite is displaced about 24° in longitude.

If, for instance, during one of its revolutions around the Earth the satellite passed over Moscow, in its next loop it will fly approximately 1,500 km. west of Moscow, somewhere over the territory of the German Democratic Republic. In the region of the equator this displacement will amount to about 2,500 km. for each loop. The altitude of the flight of the satellite over the Earth's surface is not invariable, reaching approximately one thousand kilometres.

Will the orbit change with the passage of time? Yes, it will. At first these changes will be insignificant, as the density of the atmosphere at the altitude of the satellite's movement is very small. As the satellite comes down to denser layers of the atmosphere its orbit will start to resemble a circle. The period of its revolution around the Earth which at present is 96 minutes will be diminishing.

Under the influence of the air the satellite will become hotter and hotter and will finally burn away like meteors ("falling" stars).

Radio Signals from the Cosmos

A special station for visual observation has been set up at the Kharkov Astronomical Observatory. A specially organised group headed by its director, Nikolai Barabashev of the Ukrainian Academy of Sciences, handles the reception of signals from the satellite.

The baby moon is tracked by means of radio signals received on the 15 and 7.5-metre wave-lengths, the ones on which the satellite's both radio transmitters operate. The choice of two wave-lengths is due to the fact that the 15-metre wave, located on the short-wave band, is reflected by the ionosphere. Besides, almost all amateur radio operators work in this band, since it ensures greater distance in radio transmission. The 7.5 metre wave-length, however, belonging to the ultrashort-wave band, freely penetrates the ionosphere.

This provides an opportunity of studying the reception of radio impulses from the upper layers of the atmosphere on the short and ultrashort wave-lengths. The importance of receiving these radio signals is that, firstly, the period of the satellite's revolution can be determined. The more observations we have, the greater the accuracy of the calculations.

The importance of it is that we can tell what is happening to the satellite. If the period of its revolution decreases, then the satellite is getting closer to the earth. But if it remains constant all the time, it means, the satellite is very stable on its course and, therefore, will continue to move along its orbit for a long time.

Secondly, the radio signals make it possible to investigate the upper reaches of the atmosphere, in particular the ionosphere, and the passage of radio waves at various heights. This is especially interesting at the time of maximum solar activity, when there are many spots on the sun, as is the case at the present time.

Whether it will be possible to use the satellite in the near future as relay points for T.V. broadcasts is something that cannot be answered precisely as yet, since in the observation of

the satellite we have to deal with the colossal speed of its revolution around the Earth. At such high cosmos speeds various phenomena unfamiliar to the Earth take place. Thus, before, when there was no artificial satellite transmitting radio signals, it was impossible to study the so-called Doppler Effect in radio reception, a phenomenon discovered way back at the beginning of the nineteenth century by the Austrian physicist and astronomer, Christian Doppler. The substance of it is that during the motion of the source of sound, electromagnetic or any other

Pupils of a Moscow secondary school listening to sputnik's signals

A replica of Sputnik I

type of waves in relation to the observer, the latter receives these waves in a frequency which depends on the speed of this motion. When the source of the waves approaches the radio receiving set the frequency of the vibrations increases, and when going away it drops. The Doppler Effect may be met every day in sound vibrations: a high tone in the sound of an approaching train or the motor-car changes into a low tone when passing us. It is considerably harder to investigate Doppler's phenomenon in electromagentic and light vibrations.

The Doppler Effect plays an important role in astronomy, since it makes it possible for us to determine the radiation speeds of stars, nebulae, etc.

Sputnik Is Not a Fruit of an Accidental Success

Having radically reformed the country politically and economically, the Great October Socialist Revolution unfolded the broadest of horizons for scientific progress. Freed from the

fetters of selfish capitalistic greed, science became one of the decisive factors making for the advancement of socialist society.

V. I. Lenin allotted tremendous attention to scientific development, displaying truly paternal care for the Soviet scientists, to create for them the utmost of favourable conditions for their scientific work. The party and the Government were unsparing of resources and energies to aid the scientists in every way and build up and foster new cadres of a scientific and technical intelligentsia.

Science was vastly instrumental in the entire constructive building of socialism. Its importance has tremendously grown ever since building of Communism was launched in our country. The Communist Party's general line for industrialization, for the priority growth of the production of the means of production, for the accomplishment of the USSR's prime economic goal, and for having a higher productivity of labour than under capitalism, necessitated the all-round promotion of theoretical and practical research and investigation in all branches of knowledge and the best practical application of the fruit of scientific exploration and study. Each new step in the development of socialist industry gives food for science and poses new tasks before it. In its turn science acts upon technology and production.

The successful launching of the first man-made Earth satellite is the logical result of Soviet scientific and technical progress in socialist conditions, a logical victory for socialism over capitalism. What, then, are the achievements of our science and engineering that made this success, this well-deserved triumph of our people, possible?

Achievements of Soviet Physicists

In the last quarter of a century, in the world of natural sciences, physics has forged way ahead. Rapidly growing, physical research and investigation resulted in accomplishments of staggering importance.

Speaking of the achievements of theoretical physics, we must note above all the further elaboration by Soviet scholars of the theory of relativity notably in the aspects of the non-station-

ary solution of Einstein's equation of gravitation and the problem of the law of the movement of the system of bodies.

Soviet physicists largely contributed to the development of modern quantum mechanics. An important landmark in this direction was V. A. Fok's approximated method of resolving problems of the quantum mechanics of many particles. The theory, propounded by Soviet scientists, of the inception of nuclear forces as the outcome of the exchange of light particles and the evolution by our physicists of the liquid-drop model of the nucleus essentially influenced the further development of the theory of nuclear forces.

The discovery of the Vavilov-Cerenkov effect was of pre-eminent importance. The authors of the theory of this effect are I. Y. Tamm and I. M. Frank. They have solved the problem of the radiation emitted by an electron when moving in a given medium with a velocity greater than that of light.

L. D. Landau's works on thermo-dynamics and static physics and P. L. Kapitsa's discovery of the super-fluidity of liquid helium which made it possible to predict the phenomenon of the second sound in helium, subsequently spotted in experiments, also rank among major achievements of Soviet theoretical physics.

Experimental physics, especially nuclear physics, gained signal successes. Started yet in 1924, cosmic ray investigation by means of the Wilson chamber developed into a series of experiments conducted to investigate the properties of elementary particles, artificially split the atomic nucleus, and study artificial radio-activity and the machinery and laws of the formation of positions. In 1940, the spontaneous fission of uranium nuclei was discovered in the Soviet Union. Shortly afterwards it was found that by a small enrichment of a natural mixture of uranium isotopes with uranium-235 a chain process of fission was possible with the use of ordinary water as a retarding agent.

In the peaceful use of atomic energy Soviet science has gained achievements in recent years which have brought it to the fore in world science.

V. I. Vexler's method of "auto-phasing" charged particles made the construction of powerful accelerators possible. The world's biggest 10,000 Mev proton accelerator, started this year, is based on this method which is now applied all over the world.

In the making of accelerators, the basic instrument for investigating the properties of elementary particles, our scientists and engineers have reached the highest energies ever obtained in world research laboratories. Currently research and designing is being done to construct a still more powerful 50,000 Mev accelerator. When completed, this will give another mighty impetus to the advancement of nuclear physics.

Extensive research in the physics of nuclear reactors and reactor making is being carried on in the Soviet Union. One of its results is our atomic power plant, the world's first. The successful running of this power plant served as the basis for programming the construction in the next few years of several bigger atomic power plants. Currently work is being done to design atomic engines for transport purposes and an atomic ice-breaker is also being built.

The construction of nuclear reactors has made it possible to start also the production of radio-active isotopes which are widely employed in research laboratories and at the country's industrial establishments as radiation sources and "tracer" atoms. Radio-active isotopes helped to disclose the pith of several involved processes occurring in nature and technology. They have helped, for instance, to obtain a wealth of new data about the process pattern of photosynthesis, the movement and absorption of nutritive substances in plants, the bio-chemistry of the higher nervous activity and several other biological problems.

We must indicate among the investigations of fundamental importance for the use of nuclear energy, the work done to achieve a controlled thermonuclear reaction by means of high-energy impulse discharges. This allowed us to obtain temperatures of more than 1,000,000°C in laboratory conditions for the first time

in the world. The investigation of high-energy gas discharges brings us closer to the solution of the master task of present-day science, the evolution of a reactor capable of working on heavy and super-heavy hydrogen (deuterium and tritium), and not uranium fuel. The work of I. V. Kurchatov, M. A. Leontovich, L. A. Artsimovich, and other scientists is tremendously important for the accomplishment of these objectives.

There would have been no satellite without the present-day accomplishments of radio engineering, the beginning of which is linked with the name of the Russian scientist, A. S. Popov.

In the grim years of the Civil war and postwar chaos, V. I. Lenin, the founder of the Soviet state, backed the remarkable scientist, M. A. Bonch-Bruevich, who in his Nizhni-Novgorod laboratory enriched radio engineering with his investigations in radio instrument making. He built in 1922 the world's then most powerful 12-kw radio-telephone station. The world's first radio concert programme was relayed in the Soviet Union. The USSR's radio engineering is steadily improving and is now tackling new and greater problems.

Communication with the satellite would be impossible without a knowledge of the laws of the propagation of radio waves, specifically in the ionosphere. The Earth is blanketed by a layer of air of which the atoms become ionised due to their bombardment by cosmic rays. This layer, known as the ionosphere, is "transparent" only to radio-waves of a definite frequency, reflecting back waves of other frequencies. Acad. M. V. Shuleikin was among the first to dedicate his energies to a study of the propagation of radio-waves in the ionosphere.

For twenty-five years now work has been done continually in the Soviet Union to "sound" the ionosphere by means of several dozen ionosphere stations. This all made it possible to correctly pick the radio-wave frequency for communication with the satellite. In 1930 Academicians L. I. Mandelstamm and N. D. Papaleksi theoretically substantiated and practically accomplished the phasal methods of distance measurement by

means of radio-waves. The stations now tracking the satellite are patterned on these methods.

Radar was the first means enabling man to peek into outer space for the first time way before the first Earth satellite was launched. We mean the measurement of the distance to the Moon by means of radar. This was theoretically substantiated by Acad. N. D. Papaleksi. Radio-astronomy, a new branch of science, developed as a consequence of the successes gained in advancing aerial engineering and in increasing the sensitivity of radio-receiving equipment. Radio-telescopes are now used to study the sun and investigate the so-called "radio stars".

Semi-conductor research is widespread. A signal achievement was scored in the investigation of thermoelectric phenomena. This work, done under A. F. Ioffe, resulted in the designing of thermoelectric generators transforming heat energy directly into electric power.

A great future lies ahead of semi-conductor photo-elements which transform the energy of different radiations into electricity. Silicon photo-elements convert the energy of sunlight into electricity.

The semi-conductor laboratories of the P. N. Lebedev Institute of Physics and of the Institute of Engineering Physics have elaborated the theory and investigated the electrical properties of semi-conductors. On this basis they have evolved Soviet-made specimens of semi-conductor radio apparatuses, to wit diodes and triodes. The use of semi-conductor gadgets in radio-equipment reduces size and dimensions and gives other advantages over equipment employing tubes.

Some Achievements in Mathematics and Chemistry

The rapid development of modern physics and engineering has confronted mathematicians with new tasks. Soviet scientists, continuing the glorious traditions of Russian mathematics, have introduced many new elements in the development of both theoretical and applied mathematics. Soviet mathematicians,

Academicians I. M. Vinogradov, A. N. Kolmogorov, S. L. Sobolev, M. V. Keldysh, M. A. Lavrentiev and others, enjoy well-merited fame in the USSR and abroad.

The new tasks, which have arisen before mathematics, have brought into being such trends as the theory of information, the theory of programming, the theory of computing machines. Mathematical logic has found an important application. No sphere of theory or practice is able today to get along without using complex mathematical apparatus. Fast-computing machines solving various problems of nuclear physics, aerodynamics, radio-engineering, astrophysics, etc., have been created in this country.

An eminent place in the general achievements of Soviet science which have made it possible to solve important problems to technical progress belongs to the Soviet chemistry. A valuable contribution to the development of both theoretical and applied chemistry has been made by Soviet chemists working under the guidance of Academicians A. N. Nesmeyanov, N. N. Semenov, A. Y. Arbuzov, A. P. Vinogradov, B. A. Kazansky, A. N. Frumkin, M. M. Dubinin, I. I. Chernyayev and others.

An outstanding achievement of Soviet chemistry, for instance, is the theory of chain ramified reactions, created by N. N. Semenov and his school, which is of great significance for world science. A study of a large number of model reactions has made it possible to bring out the basic laws of chain processes, to outline ways for investigation of the various elementary stages of the process and, which is more important, the means of controlling a developing chain reaction.

An exceptionally important role in the creation of commercial radium and natural radioactive elements, as well as in the industry of artificial radioactive elements, belongs to the researches carried out by V. G. Khlopin and his disciples. It was under his direction that the first preparation of Soviet radium was obtained. V. G. Khlopin discovered the law of quantitative co-precipitation which makes it possible to calculate theoreti-

cally and work out new methods for the isolation of radioactive substances.

Of much importance are the achievements in such new fields of chemistry as biochemistry, biophysics, organic chemistry of elements, and others. An important achievement in the field of the chemistry of organic compounds of elements, is the method of obtaining organic compounds of metals by means of diazo-compounds, discovered by A. N. Nesmeyanov. The theoretical and experimental researches of A. N. Nesmeyanov and his school have led to the creation of new methods in the organic synthesis of metals and elements and the production of a number of valuable new types of substances.

K. E. Tsiolkovsky's Ideas Being Realized

Solution of one of the greatest tasks ever undertaken by man—the task of overcoming the force of gravitation and entering cosmic space—would have been impossible without the creation of fast flying machines. In this field too outstanding achievements belong to Soviet scientists and designers. Fast jet planes are now flying on international air routes, evoking the admiration of specialists throughout the world.

Russian science has remarkable traditions in rocket building. More than half a century ago, when no aeroplanes even existed K. E. Tsiolkovsky, for the first time in the history of science, laid the foundations for the theory of jet propulsion and proposed a design for a rocket to travel in outer space. It was only upon the victory of the Great October Socialist Revolution that Tsiolkovsky's ideas won the recognition of the Soviet Government and science.

At the end of the '20's there appeared in the USSR groups of engineers who carried out research in a number of concrete problems of the physics and technology of jet propulsion. Tirelessly continuing his investigations into the dynamics of rockets, started by him at the beginning of the century, K. E. Tsiolkovsky had by this time arrived at the conclusion that a single rocket using chemical fuel could not achieve cosmic speed (8-11 km.

per second). In search of a solution of the problem of achieving high speeds he came to the idea of the creation of multi-stage rockets, which has proved to be so fruitful.

Thanks to the solicitude of the Communist Party and the Soviet Government the investigations in the field of jet propulsion in the USSR were included, already during the first Five-Year Plans, in the group of special researches of state importance. This made it possible at the beginning of the '30's, long before similar work began to be conducted abroad, to carry out stand tests of jet engines, and in 1933 to launch the first rocket designed by the engineer M. K. Tikhonravov for meteorological observations.

In postwar years Soviet scientists began to create ballistic and guided long-range rockets. The rocket techniques were developed and perfected both in the interests of the country's defence and for the scientific purposes.

Beginning with 1947, instruments lifted into the air by rockets have been used regularly for the study of the upper layers of the atmosphere and the processes occurring beyond its boundaries. Radiation of X-rays by the Sun was discovered, information was obtained on the chemical composition of the atmosphere at an elevation over 100 km., the concentration of free charges in the ionosphere, which plays a very substantial role in short-wave distant radiocommunications, was investigated, observations were made of the state of a living organism in a weightless condition, arising when the rocket begins its free flight, and a number of other valuable investigations were carried out broadening the horizons of scientific cognition and preparing conditions for the cosmic flight of man.

An extremely important role in preparing the launching of the artificial Earth satellite has been played by the instrument manufacturing industry. The works of such eminent scientists as D. S. Rozhdestvensky, S. I. Vavilov, G. S. Landsberg, A. A. Lebedev, laid the foundation for the development of the Soviet optical industry. This industry has furnished the most modern

optical apparatus to our astronomical observatories. It succeeded in quickly equipping the optical stations for carrying on observations of the satellite. It is now boldly competing with the American industry in the construction of giant telescopes. Yet there was a time when Russia imported even opera glasses from Germany! The designers and workers of the instrument manufacturing industry have done very much to help create the satellite.

The victory of Soviet science, which has found its expression in the launching of the first man-made Earth satellite, noted with great satisfaction by all progressive mankind, is a result not of individual record achievements of Soviet science, but of the creation of a single broad front of Soviet science, the creation of its basic-socialist industry. The socialist system has made science in the USSR mighty, the most progressive science in the world, capable of carrying out the lofty mission with which it has been entrusted, the mission of serving the cause of building Communism.

The power of Soviet science lies in its contact with practical life. Its basic distinguishing features are collectivism, a wide scope of scientific work, contact with industry, selfless devotion to the interests of the people building socialism. Soviet scientists are participating with great enthusiasm in the carrying out of the grandiose programme of Communist construction charted by the 20th CPSU Congress.

Last September, the Central Committee of the CPSU and the Council of Ministers found it necessary to draw up a long-term plan for the development of the USSR national economy for a more extensive period and charged the USSR Gosplan, the Councils of Ministers of the Union Republics, the Economic Councils, the USSR ministries and departments with the work of drawing up a national economic development plan for 1959-65. This decision states: "A major requisite for accomplishing the main task of the long-term plan is to extensively raise the productivity of labour on the basis of continued technological

progress, the mastering and broad application of the achievements of advanced science and technology in all branches of production. The new draft long-term plan should give wide scope to the development of all branches of science, theoretical research and new big scientific discoveries."

Thus, the Communist Party and the Soviet Government furnish a new stimulus for the creative work of Soviet scientists and open new broad prospects of scientific creation for the good of the Soviet Union.

How and Why Does The Artificial Earth Satellite Travel ?

The motion of the first man-made satellite, circling the Earth like a celestial body is governed by the same laws of celestial machanics as the motion of the Earth and other planets of the solar system around the sun. These laws were discovered by Kepler. Present-day celestial machanics are based on the law of universal gravitation discovered by Newton.

The satellite circles the Earth with a tremendous speed. If not for the Earth's gravity the satellite would travel in space uniformly and rectilineally. The Earth's gravity deflects the satellite from its path and makes it revolve around the Earth.

The movement of the satellite may be compared to that of a stone whirled in a sling. Holding one end of the sling in hand, it may be revolved in such a way as to make the stone fly in circles. Since we deflect the stone from its direct course the rope remains constantly tense. Its tension force is dependent on the stone's velocity and increases with its acceleration.

In the case of the satellite the role of the sling is performed by the Earth's gravitation. There is, however, an essential difference which lies in the fact that the force of gravity acting upon the satellite has a quite definite value. Therefore, the satellite's circular movement around the Earth is possible with a certain, quite definite speed only. As the path of the satellite

lies comparatively not far from the Earth's surface, its orbital velocity is some kilometres per second.

The question may arise as to why this speed is the same for all bodies regardless of weight. After all, the force of gravitation attracting a heavier body is greater. At first glance it seems that the Earth's gravity should force such a body to move along its circular orbit faster. However, if we bear in mind that the heavier the body, the more difficult it is to deflect it from its rectilinear course, in direct proportion to its weight, it becomes clear that the satellite's velocity does not depend on its weight. That is why the speed which the first artificial satellite is travelling along its course will remain approximately the same for future heavier satellites to be launched in the Soviet Union in the course of the International Geophysical Year.

It should be noted that in order to launch still greater satellites into space it will be necessary to overcome a number of additional difficulties. Therefore, all further launchings of satellites will present a new important stage in the development of science and engineering.

The force of the Earth's gravity decreases as the altitude increases. Therefore, a satellite on a more distant orbit should revolve with less velocity. The variations in the speeds of satellites on different orbits within the limits of 1,000 km. above the Earth's surface would be comparatively small. For a satellite circling the Earth at considerable distances, its velocity turns out to be much less. Thus, the Moon, which is also a satellite of the Earth and is at a distance of some 380,000 km. from the latter, circles it with a velocity of about 1 km. per sec., *i.e.* about eight times less than the speed of a satellite revolving not far from the Earth. If we keep in mind the fact that the path covered by the Moon in one complete circuit of the Earth is considerably greater than that of the man-made satellite, it will become apparent why one circuit of the Moon takes more than 8 times more time than the satellite. The Moon circles the Earth in about a month, while the satellite now makes approximately fifteen revolutions in 24 hours.

In order to launch an Earth satellite it was necessary to raise it to a great height and accelerate it to the speed necessary for movement on its orbit at this altitude. The task of establishing the satellite on its orbit is a very difficult one, the solution of which was made possible only due to the high level of rocket engineering in the Soviet Union.

The satellite moves in its orbit without expenditure of energy. The satellite has no engine. It travels exclusively due to the velocity imparted to it by the carrier rocket.

The fact that the velocity of a satellite at a higher orbit is less means that in order to establish it on such an orbit it has to be accelerated to a lesser speed. This, however, does not in the least mean that it is easier to launch a satellite on a higher orbit than a lower one. The point is that in launching the satellite the difficulties arising from carrying it to great heights are very great and with the increase in altitude they grow considerably.

Separation of the satellite from the rocket took place after the necessary velocity for the satellite had been attained. The speed of separation itself was not so great. Therefore there is nothing strange in the fact that the rocket possessing nearly the same velocity after separation as that of the satellite itself continues to move in an orbit close to that of the satellite.

The satellite launched on October 4th is a first step in the conquest of interplanetary space. For the purpose of investigating space surrounding the Earth in the future satellites will undoubtedly be launched circling at different heights, including altitudes exceeding 1,000 km. Modern science and engineering is quite capable of solving this task.

As indicated, at each particular height the satellite's movement along its circulating orbit takes place at a specific speed. If the satellite's velocity is less than required, it will be easier for

the Earth's gravity to deflect it from its rectilinear course; the satellite's trajectory will curve earthwards, and it will begin to lower. If the speed is only slightly less than necessary, the descent will be insignificant and the satellite, having approaching the Earth with an increased velocity, will then be able to climb to its previous altitude, performing the same ascent and descent periodically with each subsequent revolution.

If the difference in velocity from a circular one is greater, the descent of the satellite may be greater. In this case it may enter the dense layers of the atmosphere, and upon losing its energy due to friction caused by the air, will not be able to regain its altitude, and descending lower and lower it will get hotter and hotter, and burn away in the atmosphere.

Thus, to enable a satellite to circle in its orbit at a pre-set altitude its velocity should be quite definite. It is impossible for two satellites to travel in the same orbit with different velocities.

If at the moment of separation of the satellite from the rocket its speed is greater than that corresponding to the circular movement at a particular altitude it will be more difficult for the gravity of the Earth to deflect its path nearer to the Earth's surface.

This is exactly what has happened with the first Earth satellite. In accordance with preliminary computations the satellite was provided with such a velocity that when it separated from the carrier rocket it was greater than the required circular velocity and therefore was able to attain altitude while moving in an elliptical orbit. Therefore, it is not accidental that the perigee of the orbit (minimum distance from the Earth) is in the Northern hemisphere, while the apogee (highest point of the orbit) is in the Southern hemisphere.

If the velocity of a satellite upon separation from the rocket is considerably greater than that of a circular one, the satellite may attain a very great height, by far greater than initially attained by the rocket. If velocity upon separation from the

rocket reaches 11.2 km. per sec. or greater, the satellite will fly away into inter-planetary space.

The speed of 8 km. per sec. is called the first cosmic speed, and is necessary to establish a satellite circling close to the Earth. The speed of 11.2 km. per sec. is called the second cosmic speed and is necessary to enable a cosmic ship, launched not far beyond the Earth, to overcome its gravity and start travelling in cosmic space as a new planet of the Solar system. Development of speeds lying between the first and the second cosmic speed makes it possible to launch satellites revolving in elliptical orbits whose perigees will be close to the Earth while their apogees will be at a considerable distance. And the more the initial velocity of the satellite, the more its orbit will be stretched out, and the farther it will travel from the Earth.

The artificial satellite launched in the Soviet Union revolves at great heights reaching up to 900 km. at its farther-most point from the Earth's surface. Though the density of the air at heights of several hundred kilometres is extremely small in comparison with the density at the Earth's surface, nevertheless at the great speed with which the satellite travels it is affected by atmospheric friction. Due to the force of friction and loss of energy the altitude of the orbit's apogee will gradually decrease. The period necessary for making one complete revolution is decreasing, and on October 12 it was 95 minutes and 57 seconds. The decrease in period is not great and according to data published is 3 seconds in 24 hours.

The slow decrease in period means that the satellite will circle the Earth for quite a time. It will, however, after some time descend to a height where it will burn away due to immense heat caused by friction in the denser layers of the atmosphere.

The density of the air at great heights is not yet sufficiently known, and the data gathered through an analysis of the movement of the first man-made satellite will considerably improve our knowledge of the upper layers of the atmosphere, and make it possible to estimate accurately the life-time of satellites to be launched in the future to different heights.

The data gathered, however, on the density of the upper atmosphere gives us the right to attest that at the present level of rocket engineering it is quite realistic to speak of launching a satellite the life-time of which could be decades and hundreds of years. Such a satellite would be, practically speaking, a permanent one. Its position in the sky may be determined beforehand for quite a long period of time and with high accuracy. If we manage to launch a satellite to an orbit higher in all its parts than the 1,000 km. level over the Earth's surface, then it will revolve practically in vacuum for an indefinite long period of time.

Sputnik No. II

In line with the research programme being carried on under the IGY, on November 3 the Soviet Union launched its second sputnik. This was a new signal victory for Soviet science. As the result of a strenuous and fruitful research by a large team of scientists, engineers, technicians and factory workers, a sputnik with a payload of 508.3 kg., six times heavier than Sputnik No. 1, was made and aligned on orbit. This orbit is, moreover, much further away from the ground than that of Sputnik No. 1.

Sputnik No. 2 is outfitted with a diverse package of scientific equipment enabling a wide programme of investigation to be carried out. This includes instruments for the investigation of cosmic radiation and the ultra-violet and X-ray regions of the solar spectrum, a hermetically sealed chamber with a test animal inside (a dog), radio telemetering equipment for relaying the results of measurements to ground-borne stations, radio transmitters and also the required number of electric batteries.

The Sputnik's Orbit and Its Evolution

Sputnik No. 2 was aligned on its orbit by means of a multiple-stage rocket. In the process of alignment the rocket rose to a height of several hundred kilometres away from the ground, and then at its last stage turned to move parallel to the ground at a speed of more than 8,000 metres a second, becoming a sputnik. At the moment of alignment on orbit the stocks of fuel in the rocket's tanks had been expended and the engine had burned out. The sputnik continued to move due to the kinetic energy acquired from the take-off.

The speed imparted to the final stage of the rocket was greater than the velocity required to have the sputnik travel along a circular orbit at a constant altitude of that of the point of alignment on orbit. For that reason the sputnik follows not a circular orbit but an elliptical orbit of which the apogee is

about 1,700 km., almost double the apogee of Sputnik No. 1. Since the size of the major semi-axis of the orbit of Sputnik No. 2 is greater than that of Sputnik No. 1, the period of its revolution round the Earth is also greater, being 103.7 mins. at the beginning of its flight.

Owing to the increased period of revolution, Sputnik No. 2 makes about 14 full revolutions round the Earth in 24 hours, whereas Sputnik No. 1 made about 15 revolutions at the very beginning. The shift of each turn of the spiral along the line of longitude due to the Earth's sidereal rotation is roughly a fifteenth bigger for Sputnik No. 2 than for Sputnik No. 1. The distance apart between two turns of the ground spiral has accordingly increased by the same value.

The resistance of the Earth's atmosphere has had a braking effect on the sputnik and its orbit is thus changing in size and shape. Since the atmosphere is exceedingly rarefied at great altitudes, the braking effects acting on the sputnik are negligible. Therefore the changes in the orbital parameters are very slow. Since atmospheric density rapidly dwindles as height increases, the main braking effect is in the region of the perigee, that is at the point-closest to the Earth. At the apogee, the furthermost point away, the sputnik moves at such a great altitude that it is already in outer space, outside the Earth's atmosphere which is theoretically conjectured to reach up to a height of the order of 1,000 km. away from the Earth.

The slowing down of the sputnik depends not only on atmospheric density but also on the sputnik's shape and the ratio of its weight to the sectional area (on the so-called transverse load). When the transverse load is greater, the loss in speed is less.

Two sputniks, established at the outset on one and the same orbit, but possessing a different braking value, will, within a certain period of time, move differently, as the orbits of their flight will change with different velocities. Here the shrinking of the orbit will be chiefly due to the lowering of the apogee.

At the outset Sputnik No. 1 and its carrier-rocket travelled approximately along one and the same orbit. The difference between their periods of revolution was negligible, the period being about 96.2 mins. But now, due to the slowing down of Sputnik No. 1 being less than that of the carrier-rocket, their orbits essentially differ. The apogee of the carrier-rocket is more than 100 km, lower than that of the sputnik. According to data for November 10, the carrier-rocket's period of revolution was already roughly 74 secs. less than that of Sputnik No. 1.

The braking value for both the carrier-rocket and the sputnik changes with time, due to the changes in the orbital parameters. According as the orbit goes down, the braking increases in progression. This is lucidly corroborated by the results of observation. When the orbit falls to the height of the order of 100 km, the braking will be so great that the sputnik and the carrier-rocket will be intensively heated up and then continue to drop rapidly and burn up.

The sputnik's life-span depends on the value of the atmospheric braking. It is quite clear that the greater the period of revolution and the less the braking, the longer the sputnik's life. Calculations based on data yielded by tracking Sputnik No. 1 and its carrier-rocket warrant the presumption that the sputnik's life will be about 3 months, counting the day of its launching. This means that Sputnik No. 1 will evidently travel along its orbit till the close of this year (1957). The life of the carrier-rocket will be less than that of Sputnik No. 1 and therefore we ought to expect the carrier-rocket to burn up before the sputnik. The great period of revolution of Sputnik No. 2 and the little importance of the braking value, which is less than for Sputnik No. 1, warrants the assertion that the time Sputnik No. 2 will travel along its orbit will be appreciably longer than that of Sputnik No. 1.

Present systematisation of the results of trajectory measurements will enable us to determine fully the entire process of the evolution of the orbital parameters of both sputniks and obtain

important information about density distribution in the top layers of the atmosphere. Later, we shall be able to reliably forecast how long sputniks will live.

Observation of the Sputniks

Sixty-six special optical observatories, every astronomical observatory of the Soviet Union, and close to thirty foreign observatories are tracking the first two sputniks and the carrier-rocket of the first Sputnik. At present, a whole network of optical observatory stations is being set up in the People's Democracies. The number of foreign astronomical observatories taking part in the systematical observation of the sputniks is increasing with each passing day. The brightness of the carrier-rocket and the second sputnik have made it possible to include aerological stations of the Hydro-Meteorological Service which have piloted theodolite balloons in the system of visual observation.

As a result of optical observation, it has been determined that the carrier-rocket changes its shine. This is brought about by changes in its orientation in outer space. The shortest registered visual period of the shine is approximately 20 seconds.

Apart from visual observations, photographical observations of the carrier-rocket and the second sputnik are also taking place. Photographs taken at the Pulkovo Observatory, the Observatory of the Astrophysical Institute of the Acadamy of Sciences of the Kazakh SSR, the Observatory of the Kharkov State University, and in other astronomical observatories of the Soviet Union, as well as photographs taken at the Crimson Mountain Observatory (Chinese People's Republic), the Edinburg Observatory (Great Britain), the Dancink Observatory (Eire), the Potsdam Observatory (GDR), and others have made it possible to define more exactly the orbits of the sputniks and the carrier-rocket.

Radio observations of the sputniks have provided a mass of important data. These observations were done at stations located at different latitudes and longitudes, by radio direction finders, DOSAAF clubs, by several technical institutes, and thousands of radio fans. The material amassed is so great that only preliminary analysis has been carried out by now.

Of great importance are the measurements of the intensity of the field of radio signals received from the sputnik. These measurements were made by continuous automatic writing machines and by individual measurements taken at definite intervals. The results of the measurements of the intensity of the field of radio signals have made it possible to evaluate the absorption of radio waves in the ionosphere, including those areas which lie above the maximum ionisation of the main ionospheric layer F_2 and therefore are inaccessible to ordinary measurements taken from the Earth's surface. These measurements permit us to judge of the possible means of transmitting radio waves in the ionosphere.

The results of radio signals received from the sputniks and the measurements of their levels has determined that these signals on the 15-meter band were received at distances far exceeding those determined by direct vision, for they were as great as 10, 12 and even 15,000 kilometres, and in some cases even greater.

The fact that the sputnik, moving on an elliptical orbit, occupies various positions in relation to the basic maximum of electronic concentration in the Earth's atmosphere is of great interest. In analyzing the materials gained through radio observation, it is of importance to ascertain whether, at a given time, the sputnik was above or below the true height of the maximum of electronic concentration of layer F_2, information that is obtained on the basis of high-frequency characteristics of the ionosphere recorded by ionospheric stations. If, in the Southern Hemisphere, the sputnik moves above the ionosphere, than in the Northern Hemisphere, at times it is above the maximum ionisation of this layer, at other times it is lower, and at

still other times it is close to this maximum. Such conditions create a great variety in the means of propagating short waves over great distances. One such alternative is the reflection from the Earth's surface of radio waves coming from above, that have passed through the layer of the ionosphere which are then followed by a one-tact reflection from the ionosphere in areas where the threshold frequencies are of sufficient value.

In other instances, radio waves coming from above at a certain angle to the ionosphere are considerably refracted and therefore penetrate into this area which lies beyond the limits of straight geometrical vision.

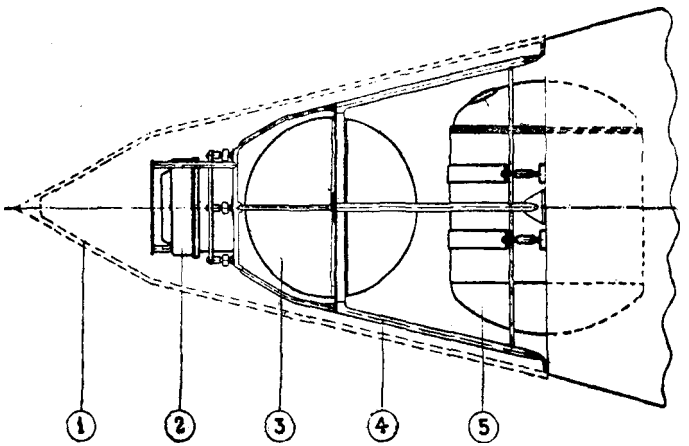
When the sputnik is close to the area of maximum ionisation of the atmosphere there arise extremely favourable conditions for propagating radio waves through ionospheric radio wave transmitters. In several cases, as practice has shown, the radio-waves pass into the receiver after having circled the Earth along a greater orbit instead of following the shortest possible course. In several cases the radio signals produced a world-wide echo. In other cases the measurements of the intensity of the field were greater than they had been thought to be, according to the law of inversed proportionality of the first stage of the distance which also indicates the existence of wave-transmitting channels in the ionosphere.

Interesting results have been obtained on the basis of Doppler's Effect by tape-recording the changes in the tone of beats between the frequency of radio-waves sent out by the sputnik and frequency of vacillations of the local heterodine. Many such tape recordings have been made, and their results are now being analyzed.

Undoubtedly, the final analysis of data based on radio observations of the sputniks will bring about important discoveries of the peculiarities in the ionisation of the upper areas of the ionosphere and also of the absorption and nature of the radio-waves propagated therein.

Structure of Sputnik No. 2

As has been indicated above, Soviet Sputnik No. 2, at variance to Sputnik No. 1, is the last stage of a rocket, housing all the scientific and measuring equipment. This way of housing equipment appreciably simplified the task of ascertaining the sputnik's bearings by means of optical observation, since, as the experiment with Sputnik No. 1 has shown, the tracking of the carrier-rocket proved to be far simpler than the tracking of the sputnik itself. The brilliancy of the carrier-rocket is greater than that of Sputnik No. 1 by several stellar magnitudes. The total weight of the package of equipment, the test animal and the electric batteries in Sputnik No. 2 is 508.3 kg.



Arrangement of apparatuses in Sputnik II. 1. A protective cone which dropped off when Sputnik II had entered its orbit. 2. An instrument for research of solar and X-ray radiation. 3. A spherical container with instruments and radio transmitters. 4. A frame on which the apparatus is placed. 5. A hermetically-sealed cabin with a dog.

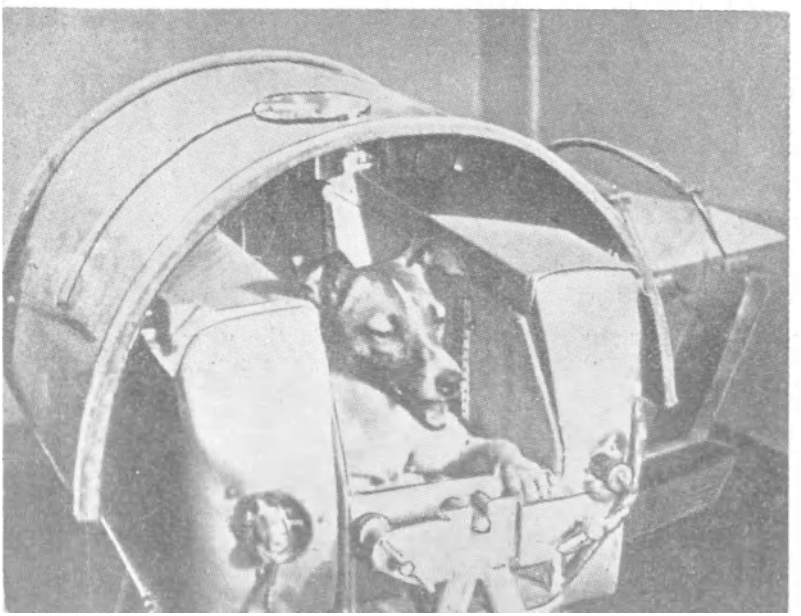
In the nose of the final stage of the rocket, fixed to a special frame are instruments for studying solar radiation in the ultraviolet and X-ray regions of the spectrum, a spherical container

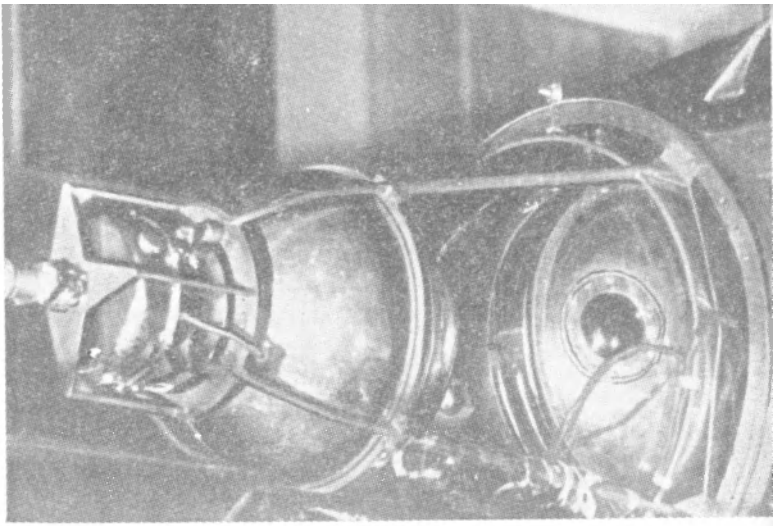
with radio transmitters and other instruments, and a hermitically sealed chamber with a test animal (a dog) inside. The apparatus for cosmic ray investigation is fixed to the rocket's body. The devices and containers installed in the rocket are shielded from the aero-dynamic and heat effects of the rocket's passage through the dense layers of the atmosphere by a special protective cone. After the last stage of the rocket was established on its orbit, the protective cone was discarded.

The radio transmitters, placed in the spherical containers, functioned on frequencies of 40.002 and 20.005 megacycles per second. The electric batteries, the heat regulation arrangement, and also sensitive elements for recording temperature fluctuations and other parameters were also placed in this container. In structure the spherical container resembles the first sputnik.

The signals emitted by the radio transmitter working on 20.005 megacycles (15 metres) were of a telegraphic order averaging around 0.3 secs. in length, with a pause of the same

Laika in the hermetically-sealed cabin of Sputnik II





Unit of containers with scientific equipment of Sputnik II.

time in between. Due to changes in some of the parameters inside the spherical container (temperature and pressure) the length of the signal and the pause also changed within definite limits.

The transmitter working on 40.002 megacycles (7.5 metres) functioned under a continual emission regime. The conformity of the two transmitters to the indicated frequencies ensured investigation of the propagation of the radio waves emitted from the sputnik and the measurement of its orbital parameters. Moreover, reception of signals from the sputnik in all ionospheric conditions was guaranteed. The choice of the wavelengths and also the ample power of the transmitters enabled the broadest community of amateur radio operators to track the sputnik, along with stations specially assigned this task.

The hermetically sealed chamber in which the test animal (a dog) was housed, was cylindrical in shape. To provide conditions to maintain normal life, it had a stock of food and

an air-conditioning arrangement consisting of a regeneration installation and a heat regulation system. Along with this, the chamber also had inside equipment for recording the pulse-beat, breathing and blood pressure, instruments for taking electrocardiogrammes and also sensitive elements for measuring a number of parameters characterising the conditions inside the chamber (temperature, pressure).

Both the chambers for the test animal and the spherical container were made of aluminium alloys. They had a polished surface, specially treated to impart the required coefficients of emission and absorption of solar radiance. The heat regulating arrangement inside the spherical container and the animal's chamber maintained the set temperature, deflecting the heat into the hull by compulsory gas circulation.

Apart from the indicated equipment, the body of the last stage of the rocket had on it radio-telemetering measuring equipment, instruments for temperature measurement, and electric batteries to feed the scientific and measuring instruments. The temperature in the outer surface and inside the animal's chamber and also of the individual devices and elements was ascertained by means of temperature senders fixed onto them. The radio-telemetering equipment relayed to ground-borne stations all recordings of all the measurements taken on the sputnik. The broadcasting of this data was done periodically according to a special programmed arrangement.

The research programme involved in the taking of measurements by Sputnik No. 2 was to cover a period of 7 days. By now it has been carried out. The sputnik's radio transmitters and also the radio-telemetering equipment have stopped working. The further tracking of the motion of Sputnik No. 2 to study the characteristic features of the top layers of the atmosphere and forecast its flight is being done optically and by radar. The sputnik enabled scientists to conduct for the first time several experiments in the top layers of the atmosphere, experiments previously unthinkable.

The Sun's Short-Wave Radiation

Investigation of the short-wave ultra-violet radiation of the Sun is of paramount scientific and practical interest for physics, astrophysics and geophysics. As investigation carried on in recent years has shown, apart from the visible light, the Sun emits a radiation encompassing a wide range of wave-lengths, from X-rays with a wave-length of the order of several one hundred-millionths of a centimetre, to radio waves of several metres in length.

The emission of the short-wave region of the solar spectrum (remote ultra-violet and X-ray radiation), and also of radio waves is linked with the physical processes taking place in the exterior layers of the Sun's atmosphere (the chromosphere and the corona, regions we have little knowledge about), and has the most serious effects on the Earth's atmosphere. Investigation of the Sun's chromosphere is concentrated mainly on the spectral line of hydrogen, on a 1,215 angstroms (an angstrom is one hundred millionth of a centimeter), located in the remote ultra-violet region of the spectrum. The study of the corona is limited to the region of soft X-rays (from 3 to 100 angstroms). The corona, which is comprised of extremely rarefied matter, has a temperature close to 1,000,000°C, but, furthermore, apparently the corona has regions with a still higher temperature. To this day the nature of the corona is still much of an enigma.

The aggregate energy of this Sun's short-wave radiation is comparatively small, being tens of thousands of times less than the energy the Sun emits as visible light, but it is this radiation that exceedingly greatly affects the Earth's atmosphere. The reason is that short-wave radiation is exceedingly active and can ionise air molecules, thus engendering the ionosphere, which is the strongly ionised upper layers of the atmosphere. According to existing notions, the nether layer of the ionosphere which stretches at a height of between 70 to 90 km (the D layer) is formed through the ionisation of air molecules by the emission of the spectral line of hydrogen from the chromosphere.

while the next layer, at the height of between 90 to 100 km (the E layer), owes its ionisation to the corona's X-ray emission.

The condition of the exterior layers of the Sun and of the ionosphere is not constant; it changes continually. It has been found that there is a close link between solar activity, the appearance of so-called chromospheric eruptions, and ionospheric absorption of radio waves, resulting in the interruption of radio communication. This compels the assumption that there is a direct bond between the variations in the intensity of the Sun's X-ray radiation and ionospheric processes.

The Earth's atmosphere fully absorbs the Sun's ultra-violet radiation, gating only a region of proximal ultra-violet radiation, contiguous to the violet in the visible spectrum. These absorbing effects of the terrestrial atmosphere shield living organisms from the Sun's deadly short-wave radiation. But at the same time it makes investigation of this radiation from the ground impossible. The absorption by the molecules of air is so great that to observe this short-wave radiation we must be altogether outside the Earth's atmosphere, and place our instruments on a sputnik. Though the use of high-altitude rockets has also yielded valuable results, only the sputniks enable us to carry on systematic measurement, over long periods of time necessary to study the variations in the intensity of short-wave ultra-violet radiation.

Three special photo electronic multipliers, set at an angle of 120° to each other, serve as receptors of radiation. Each photo multiplier is consecutively covered with several filters of thin metallic and organic film and also of special optical materials, making it possible to single out the different bands in the X-ray region of the solar spectrum, and the hydrogen line in the remote ultra-violet region. The electric signals given out by the photo-multiplier trained on the Sun were amplified by radio arrangements and telemetered to ground-borne stations.

Owing to the continual change in the sputnik's bearings with respect to the Sun and also to the fact that part of its orbit was not lit by the sun for a certain period of time, the electric

circuits in the apparatus were switched on, in order to feed the batteries, only when the Sun came within the range of vision of any of the three light receptors. This was done by means of photo-resisters lit by the sun at the same time as the photo multipliers, and by an automatically working arrangement.

Along with sputnik observation of solar radiation, this was done also by the entire network of ground-borne "Sun service" stations incorporated in the IGY programme. These observations were carried on by astrophysical observatories and by stations studying the ionosphere and receiving the Sun's radio waves. Systematisation of all these observation materials will enable us to draw the first conclusions as to the connection between the Sun's ultra-violet and X-ray radiation and the processes taking place in the Sun's chromosphere and corona, and likewise the state of the Earth's ionosphere. This data will pave the way for subsequent systematic observation.

Cosmic Radiation Study

In the womb of outer space the atomic nuclei of different elements are accelerated and acquire very great energies. The cosmic radiation that thus originates affords the opportunity of investigating outer space at great distances away from the Earth and even from the solar system itself. As they travel towards the Earth from their birth-place, the cosmic rays undergo the effects of the surroundings through which they pass. Due to a whole number of processes the constitutional structure and intensity of this radiation change. In particular, the number of cosmic ray particles will increase, if there be intensive explosions on the Sun and if the conditions are created for accelerating atom nuclei to great energies. Thus, there arises an additional stream of cosmic rays, sent out by the Sun.

The Sun is also a source of corpuscular radiation. In the streams of corpuscular rays there are intensive magnetic and electric fields which affect cosmic radiation. Cosmic rays assist us in studying these streams at great distances away from the Earth.

Cosmic ray particles are strongly deflected in their passage through the Earth's magnetic field. Only particles with very great energies will unhamperedly reach any spot on our planet. The less the energy of the particles, the smaller the places on Earth accessible to them. Particles with small energies reach only the polar regions. Thus the Earth is surrounded in its way by an energy barrier which furthermore decreases in height from an equatorial peak, as geomagnetic latitudes increase. Equatorial regions are reached only by cosmic protons with energies of more than 14,000 Mev. The Southern parts of the Soviet Union are accessible only to particles possessing energies of more than 7,000 Mev. Finally, the neighbourhood of Moscow is reached by all particles with energies of more than 1,500 Mev. The measurement of cosmic rays at different latitudes enables us to ascertain how many particles there are in the cosmic radiation and what energies they have. The dependence of the number of particles in cosmic radiation on the latitude, the so-called latitude effect, determines the distribution of the particles according to their energy, *i.e.* the energy spectrum of cosmic radiation.

Due to a number of processes taking place in outer space and involving cosmic rays, their number and constitution changes. In some cases, as, for instance, when particles appear on the sun, there are reasons to expect that only the number of particles with small energies increases, whereas the number of particles with high energies remains without change. In contradistinction, changes in the Earth's magnetic field and the effect of the Sun's corpuscular radiation on cosmic rays change not only the number of particles with small energies but also the number of particles with high energies.

To elucidate the nature of the changes cosmic rays undergo, we must not only establish the fact of the increase or decrease in the intensity of cosmic radiation, but also determine how the number of particles with different energies will change. Moving at a speed of 8 km. per sec., the sputnik crosses from one latitude to another in a very short space of time. Thus by sput-

nik measurements of cosmic radiation we can ascertain its latitude effect and thereby the distribution of particles of this radiation according to their energies. The fact that there is a great number of these measurements is particularly appreciated. Therefore the sputnik will help us to trace not only the changes in the intensity of cosmic radiation but also in its composition.

The particles comprising cosmic radiation are recorded aboard the sputnik by means of counters of charged particles. When the counter gates an electrically charged particle, there arises a spark sending an impulse to a radio arrangement of semi-conductor triodes of which the designation is to count the number of cosmic ray particles and send out a signal when a definite number of particles will have been counted. After the signal to the effect that a definite number of particles have been counted is broadcast, the cosmic ray particles are again recorded with a new signal sent off as soon as the same number of particles will have been counted. By dividing the number of recorded particles by the time in which they were counted we shall obtain the number of particles the counter gates each second, or in other words, we shall know the intensity of cosmic radiation.

The sputnik had two identical devices for recording charged particles. The axes of the counters in both devices were reciprocally perpendicular.

Preliminary systematisation of sputnik data on cosmic radiation has shown that both devices functioned normally. The dependence of the number of cosmic ray particles on the geomagnetic latitude was clearly discernable. Systematisation of the great number of measurements of the energy spectrum of virginal cosmic particles makes it possible to investigate the changes that come with time in this spectrum and compare them with the processes which took place at that time in the outer space around us.

Study of Biological Phenomena in Conditions of Space Travel

To study several medical and biological questions, the sputnik had inside a specially hermetically sealed chamber containing a test animal (a husky named "Laika"), measuring equipment to record the animal's physiological functions and also equipment for air regeneration, feeding, and removal of the animal's excretions. Equipment designs took into consideration the requirement for the most stringent economy in size and weight, coupled with a minimum consumption of electricity.

Functioning over a long period of time, the apparatus ensures by means of a radio-telemetering arrangement recording of the pulse-beat and breathing of the animal, his arterial blood pressure and cardial biopotentials, the temperature and the air pressure inside the chamber, etc.

To regenerate the air inside the chamber and maintain the required gas composition, highly active chemical compounds, giving off the necessary amount of oxygen for inhalation and absorbing carbon dioxide and the surplus of vapour, were employed. Their amount in chemical reactions was automatically controlled. Due to the absence of air convection in conditions of zero-g, an arrangement for compulsory ventilation was installed in the animal's chamber. A set air temperature in the chamber was maintained by a heat regulating arrangement. To give the animal food and water during flight, the container had special feeding devices.

The dog Laika, sent up aboard the sputnik, went through preliminary training. It was gradually accustomed to protracted sojourns in special clothing, in small hermetically sealed chambers, to the senders fixed in different places of its body to record its physiological functions, and so on. The dog was also trained to bear up under overstrains. The animal's resistance to the effects of vibration and some other factors was ascertained in laboratory conditions. After long training the animal was able, over a period of several weeks, to remain calm inside the

hermetically sealed chamber, thus enabling the necessary scientific investigations to be carried out.

The study of biological phenomena involved in cosmic travelling of living organisms was made possible thanks to extensive advance experimenting with animals in conditions of short-lived flights aboard rockets up to altitudes of between 100 and 200 km. These experiments were carried on in the USSR over a number of years.

At variance with earlier investigations, the animal's travel aboard the sputnik makes it possible to study protracted effects of zero-g. So far zero-g effects could be studied aboard aircraft, only within a matter of a few seconds, or in vertical upward rocket flights, only in the matter of a few minutes. The sputnik makes it possible to study the condition of a living organism in a zero-g state lasting several days.

The experimental data derived through the fulfilment of the programme of medical and biological research is currently being subjected to most detailed and thorough study. We can say already right now that the test animal stood up well to the protracted effects of acceleration when the sputnik was being aligned on orbit and to the subsequent state of zero-g which continued several days. The information received shows that the animal's condition was satisfactory throughout the entire experiment.

Without doubt, these investigations will largely contribute to coming successful interplanetary voyages and will pave the way for evolving the means to guarantee safety to human beings on space voyages.

The Upper Atmosphere and Its Investigation with the Help of the Man-made Earth Satellites

The outstanding Soviet accomplishment in the field of rockets and artificial Earth satellites opens up new horizons for the widest programme of diverse scientific experiments earlier thought impracticable. Thus, with the help of the new means at our disposal, we can study the upper atmosphere and cosmic rays, detect in ultra-violet rays different astronomical objects, verify the theory of relativity, observe the Earth's blanket of clouds, spot gravitation surface anomalies and tally the number of micrometeors.

The upper atmosphere is now usually understood as the region above the altitude of 30 to 40 kilometres. Of great practical interest, it is the medium in which man-made satellites will revolve and through which the routes of future space ships will strike. Furthermore, it is the medium where radio waves propagate. The strata and regions with increased ionisation to form within this upper atmosphere either reflect or disperse these waves, thereby creating the necessary conditions for their propagation over great distances. At the same time, given certain factors, the upper atmosphere becomes now and again a medium absorbing radio waves.

The processes in this part of the atmosphere have as their characteristic trait a whole series of specific features, usually not characteristic of its lower regions. These include peculiarities linked with the unceasing chemical modification of atmospheric molecules and atoms and their ionisation under the effects of rigid ultra-violet, X-ray, and corpuscular solar radiation. (Corpuscular solar radiation consists of rapidly moving elementary

particles, electrons, protons, neutrons, alpha-particles, etc.) Furthermore, in the top layers of the upper atmosphere the change in its relative atomic composition is substantial, being expressed in a preponderance of lighter molecules and atoms due to gravitational effects. The circulation of an ionised, electricity-conducting atmosphere through the Earth's constant magnetic field has as its concomitant the excitation of electric currents causing diverse variations in this field.

Valuable information about upper atmosphere circulations was derived through optical and radar observation of drifting meteor traces and also through observation of solar and lunar tidal phenomena in the atmosphere. We customarily think of oceanic tides, but in the upper atmosphere these phenomena are far more intensive. As a result we were able to roughly characterise the properties of the upper atmosphere. The temperature in its upper part was thought to be several thousand degrees, and density, around 1,000 million molecules and atoms in 1 cu. cm. at the altitude of some 300 km. We must keep in mind the fact that ground air density is over 10,000 million times more.

It was conjectured that the upper atmosphere had three or four distinctly different ionised strata. But our knowledge of the sun's rigid ultra-violet and X-ray radiation which is absorbed by the atmosphere and do not reach the Earth was too hypothetical until quite recently. Upper atmosphere dynamics, linked with photochemical transformations and ionisation, remained vague. We also knew very little about the Sun's corpuscular radiation, the cause of the Auroras and ionisation anomalies. But without an accurate knowledge of these disturbing agents it is hard to construct a general dynamic theory of upper atmosphere processes.

Lately we have been intensively investigating emissions, that is, definite types of radiation from the upper atmosphere. In this way we obtained a wealth of valuable data. Thus, using the spectroscopic method, we found that at an altitude of some 100 km. the terrestrial atmosphere is cooler above the equator

and warmer above the polar regions. This is an exceedingly essential factor for the origination of circulation. A higher temperature in the Polar regions results in a very peculiar structural composition of the top layers of the atmosphere, known as the exosphere. As you might know, in an extremely rarefied medium ionised particles can move only along the lines of magnetic force. That is why masses of ionized particles, or pillars jut out above the warmed sections and are sometimes spotted in the twilighted exosphere. These are the so-called auroral flashes. Interesting data on ionisation was obtained through radar investigation of these auroras.

Meteors greatly influence the properties of the upper atmosphere. When they dive into the atmosphere, highly charged oxides of nitrogen and shock sound-waves, provoking medium density vacillations, are formed. The latter originate in the upper atmosphere also when infra-sound waves produced by winds, oceanic surface-disturbances, and the like—penetrate from the nether, ground atmosphere layers. Thus, talking figuratively, the outer layer of the atmosphere somewhat resembles frothy waves during a storm.

In recent years substantially novel results have been obtained by using rockets for upper atmosphere research. It was found that density and temperatures dropped above altitudes of between 150 to 200 km. Exceedingly valuable results were obtained in determining ionisation. It was found that there took place a gradual smooth increase of ionisation, coupled with a great number of very shallow maximums which were hard to identify with the very distinct, simple layers conjectured earlier. Further, the real ionosphere proved to be lower than surmised before. Rigid ultra-violet and X-ray solar radiation was directly measured.

Measurement of rigid solar radiation absorption proved upper atmosphere density to be less. But the short-termed nature of rocket research is an essential drawback.

Artificial satellites provide for long and continual observa-

tion above various points of the globe and therein lies their basic advantage.

Observation of rigid ultra-violet, X-ray and corpuscular solar radiation is most essential. Here it is very important to find the link between corpuscular inroads, on the one hand, and the rapid variation in the Earth's magnetic field and the absorption of radio waves, on the other. It is also very important to determine ionisation changes in space. By analysing magnetic field variations we may disclose a system of upper atmosphere currents. A study of the distribution of cosmic rays, which are charged particles, will help us to gain cognition of the outer magnetic field around the Earth, found lately not to dove-tail with earlier conceptions.

Initial data indicating the constancy of the Soviet satellite's period of revolution bespeaks insignificant friction and, hence, small density in the upper atmosphere. Valuable data about ionisation and radio-wave propagation will also be deduced from material about the audibility of the satellite's radio signals. An investigation of radiation from disturbance of the atmosphere by bodies moving with velocities of a cosmic order is of great scientific interest. This radiation will be particularly intensive when the satellite slows down somewhat and shifts to lower strata, exciting and charging the molecules and atoms of the surrounding medium, like a huge artificial meteorite. Co-ordination of all these observations with other ground observations slated in the current International Geophysical Year programme is particularly valuable.

Investigation of the Earth's Magnetic Field by means of Satellites

The Earth is surrounded by a natural magnetic field. Its properties, as for instance its guiding influence upon the magnetic needle has already long been made practical use of, although the nature and the origin of the field itself are still unknown. The terrestrial magnetic field influences the movement of the charged particles coming to the Earth from the Sun out of space or formed in the upper layers of the atmosphere when the latter are ionised by the ultra-violet rays of the Sun. This explains such geomagnetic effects as the latitudinal distribution of intensity of cosmic rays and the frequency of visibility of the Northern lights, the polarisation of radio-waves reflected from the ionosphere, and many other phenomena.

Until recently, measurements of the terrestrial magnetic field were made either on the Earth's surface or in its direct vicinity (from aircraft), and only lately Soviet scientists made several measurements with the help of rockets reaching heights a little over 100 km. A mathematical analysis of the data of terrestrial measurements led to a number of interesting conclusions. It appeared that the field observed on the Earth's surface should be considered as consisting of two parts: One due to sources within the Earth, and the other, to extra-terrestrial sources.

Although the share of the extra-terrestrial source of the field is small, from one to three per cent, and its size is just within the limits of accuracy of mathematical analysis, there can be no doubt of its reality. The existence of the external field is confirmed by the swift changes in the terrestrial magnetic field, known as diurnal variations of the Earth's magnetism,

magnetic disturbances and magnetic storms. These changes are closely inter-connected with many extra-terrestrial phenomena: Solar activity, the state of the ionosphere, the Northern lights, cosmic rays.

A mathematical analysis of these changes shows that their sources are extra-terrestrial. Unfortunately, the analysis of the data of terrestrial observations can neither indicate the exact location of these sources of the field, nor determine their nature. Other data is required for this purpose.

Investigation of diurnal variations, magnetic storms and the phenomena connected with them led scientists to assume that the external magnetic field may be due to systems of electric currents existing beyond the Earth. The most likely place where such currents can originate are the upper conduction layers of the atmosphere (the ionosphere).

It is also assumed that currents may exist beyond the ionosphere. The sources of extra-ionospheric currents may be the charged particles, corpuscles, emitted by the Sun, captured by the Earth's magnetic field and revolving around the Earth in the plane of its magnetic equator at a distance of several tens of thousands of kilometres from the Earth. The extra-ionospheric currents become intensified during magnetic storms when the Earth finds itself in the path of the intensive corpuscular streams ejected by the active regions of the Sun. During this period their magnetic field shifts the zones of the Northern lights nearer to the Equator and reduces the intensity of cosmic rays.

The existence of sources of a magnetic field in the ionosphere has been confirmed at present by direct magnetic measurements made with rockets.

During the International Geophysical Year great attention is being devoted by Soviet scientists to a study of the Earth's external variable magnetic field and its connection with solar and other geophysical phenomena. The variations of the magnetic field will be recorded uninterruptedly by a large number of stations. It is also planned to measure the magnetic field

from satellites and rockets. Magnetic measurements by satellites will make it possible to survey the magnetic field enveloping the Earth at great heights. The object of magnetic measurements by satellites may be to verify the existence of extra-ionospheric currents, to obtain data on the ionospheric system of currents, and extend our knowledge of the main part of the field created by the sources within the Earth. Measurements made on satellites will help to verify whether the streams of solar particles are neutral or consist of electrically-charged particles of any given sign.

Measurements of the magnetic field may be made by magnetometers installed on a satellite, the results of the measurements being broadcast to the Earth.

Data on the field created by the extra-terrestrial sources may be obtained from a comparison of the measurement recordings of the field and the theoretical computations made on the assumption that the field is created only by sources within the Earth. A knowledge of the field of the external sources at great heights will promote a better understanding of its role in any given geomagnetic effect. It is not excluded that in some cases this role may be very considerable. In particular, it is possible that the recently-established non-coincidence of the geomagnetic equators of Earth, as determined by terrestrial magnetic measurements and by measurements of the intensity of cosmic rays, may be due to the action of the cosmic rays of the external sources of the field upon the charged particles.

By observing the decrease in intensity of large magnetic anomalies from great heights we shall be able to judge whether the sources of these anomalies lie near the surface of the Earth or at a great depth.

Breaking into Cosmos

In the course of the present International Geophysical Year Soviet scientists intend to study the atmosphere with the help of various apparatuses at heights of up to 1000 kilometres, that is, to explore practically the whole of the atmosphere surrounding the globe.

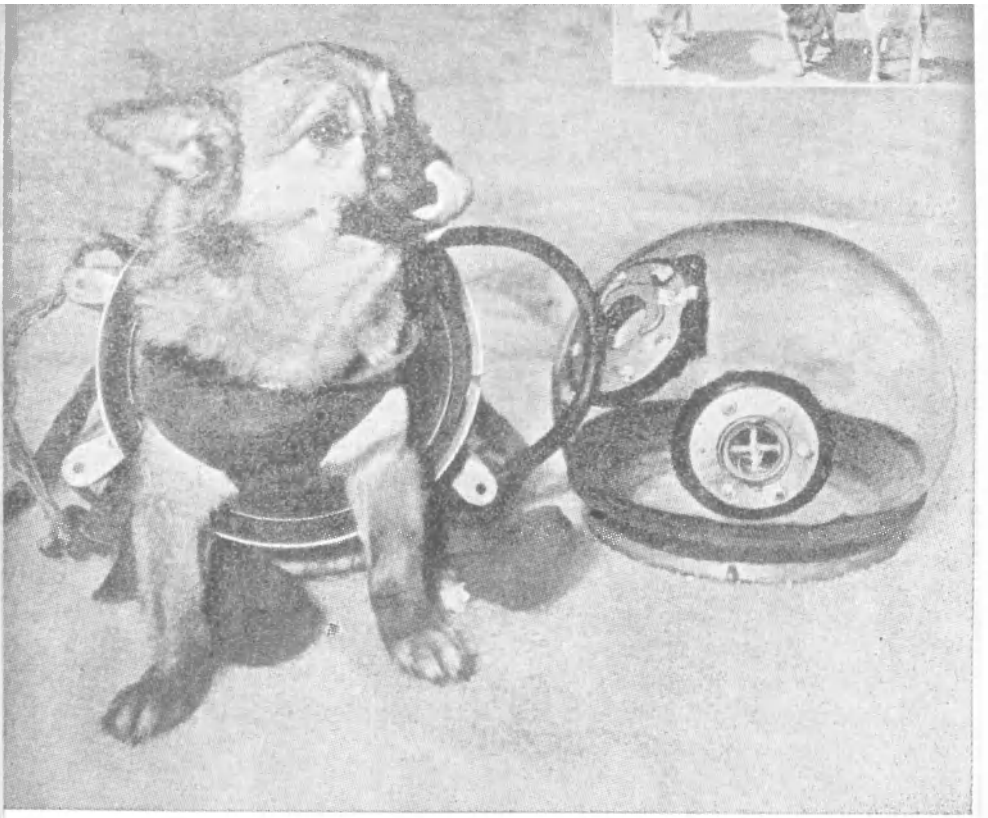
The attack upon the cosmos raises scores of questions which Soviet scientists must answer in order to be able to conquer world space.

For instance, why does a deep-sea fish swell and burst when it is brought to the surface of the ocean? Because its organism is adapted to life under a layer of water weighing scores of tons. Does that mean that the same thing will happen to man who lives at the bottom of the atmospheric ocean if he rises high above the Earth?

Soviet scientists decided to try it out on animals. They placed dogs in a pressure chamber and reduced the air pressure 30 millimetres of the mercury column for two-three hundredths of a second. The animals "flew up" as it were for an instant to a height of 22 thousand metres. Thirty seconds later subcutaneous swellings appeared on the bodies of all the dogs. What happened to them?

It was found that on rising to a height of more than 8000 metres the nitrogen which the tissues of a living body contain in a dissolved state is transformed into gas. Bubbles appear in the vessels. At a height of 19,000 metres all the tissue liquids begin to evaporate. In all parts of the body, even in the heart cavity, water vapour, nitrogen and carbon dioxide appear. The higher the living organism rises the more rapidly and intensively does this destructive process take place. Can it be prevented? Yes, without doubt.

Flights to high altitudes must be made in airtight cabins. The idea of utilizing such cabins with normal pressure inside was expressed as far back as 1908 by the Russian scientist K. E.



Maishka lands from an altitude of 70 miles

Tsiolkovsky. But how will a living organism feel in such a cabin? Besides that, could a human organism stand the tremendous acceleration which arises when a rocket is sent up?

Man can easily stand any speed. Speed, but not acceleration. Soviet scientists were afraid that the overcharge arising in cases of great accelerations would disturb the activity of the organism and even destroy it.

Does that mean that it is impossible for man to fly in a rocket? Only an experiment could supply an answer to this question.

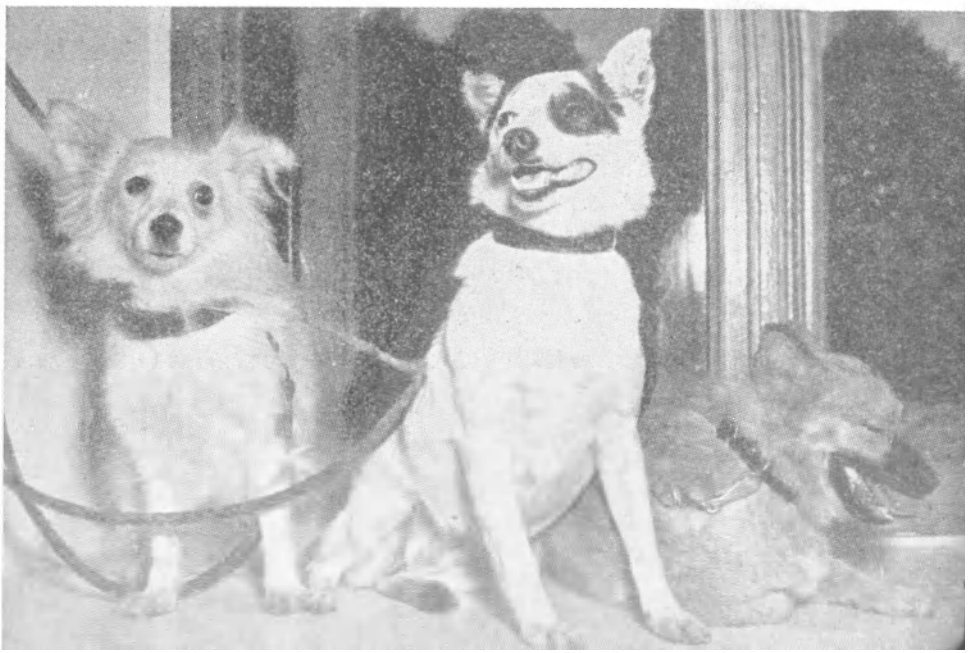
There was still another important problem that had to be rapidly solved.

Interplanetary space is filled with deadly cosmic rays. The atmosphere surrounding the Earth holds back the greater part of these rays. Only one-fifth of cosmic radiation penetrates to a height of 40 kilometres through the thick layer of atmosphere. The only way of finding out how dangerous these rays are in the upper strata is to send up animals to the high altitudes.

Such experiments were performed. Stratosphere balloons filled with hydrogen were kept for 24 hours at a height of about 27 kilometres carrying grey mice in their light gondolas. Biologists attentively observed the rodents after their flight. The scientists were attracted by the fact that in many young mice two-three months after the flight the fur began to grow markedly grey in the sacrum-lumbar region. This is a typical symptom of radiation sickness. However, no other morbid symptoms were observed.

Susliks, too, were sent up to the stratosphere. The journey did them no harm. But then again the scientists got an alarm-

Some of the first space travellers



ing signal. On returning from such a flight worms continued to reproduce every day as before, but their offspring degenerated rapidly. The seventh generation of the irradiated worms perished without maturing.

It was found that at a height of 22.9 kilometres the power of cosmic irradiation amounts to 15 milliroentgens a day, which is 150 times more than at sea level. Fifteen milliroentgens a day is an insignificant dose, but the radiation may consist of different particles. It becomes dangerous if it mainly consists of heavy nuclei with an exceptionally great penetrating capacity. Not only the amount of radiation but its composition changes with altitude. The increment of heavy nuclei is particularly noticeable beginning with the height of 35-40 kilometres.

Soviet scientists were faced with a number of new questions: is it true that at high altitudes the danger of meteorites is so very great, that a meteorite weighing half of kilogram can break with force a layer of aluminium several centimetres thick? What are the electric properties of the ionosphere at different altitudes? Only experiments could supply answers to all these questions.

Soviet scientists decided to undertake experiments with dogs and began to prepare them for the voyage to great heights. Several tiny metal apparatuses were inserted directly into the bodies of the animals. With the help of these devices it would be possible to register every inhalation, every beat of the heart, the temperature of the skin and the activity of the organism as a whole. The dogs were kept in a pressure chamber, they flew in airplanes and fearlessly got into the rocket and after the tests jumped to the balances of their own accord. Only animals which during the 7-10 days endured a three-hours' stay in the cabin were selected for the flights. Among them were two dogs called Tsigan and Tezzi.

Strapped to special stands in the head part of the rocket Tsigan and Tezzi waited until they would be let out to play. But the men were in no hurry. On the contrary they moved

away for a whole kilometre from the powerful projectile. When only five minutes were left until sunrise the huge rocket suddenly disappeared in a cloud of fire and smoke.

The rocket gained speed as it rose higher. It already began to make 1170 metres a second. A film shot during the flight showed how the heads of the dogs were pressed to the floor. The fivefold overcharge made itself felt. The dogs began to weigh five times more than on Earth. However, no morbid phenomena were observed in the dogs. That means that such acceleration is not dangerous. The human organism can also stand it.

Not without reason was the rocket sent up immediately before sunrise. The people that watched it were still in the shade but the rocket already shone like a star in the bright rays of the Sun. When it reached its highest point—a height of 110 kilometres its fuel came to an end and its motor stopped. For some time the huge projectile continued to fly upward by inertia, then it halted and, drawn to the Earth, began to fall. Those who followed the rocket with the help of apparatuses saw a second little star separating from it. That was the cabin with the two dogs.

Unimpeded fall began and the state of weightlessness set in. The airtight cabin developed tremendous speed. But the nearer the Earth the more compact is the atmosphere. The fall became slower. Finally, parachutes opened automatically and the cabin smoothly fell to the ground. Its designer equipped it with a good buffer.

The first stage of the researches was successfully completed. The flight did no harm to the dogs. As the next step it was decided to send dogs up not in a common chamber but in special togs made of rubberized cloth and a transparent plastic hood. The stock of oxygen in three cylinders (about 900 litres) lasted the animals for two hours. The recording apparatuses, a parachute and the oxygen were placed on a catapult car to which the dog in togs was tied. The total weight of the car was 70 kilo-

grams. Two catapult cars with the dogs were placed in the bow of the rocket.

At a height of 80-90 kilometres the right hand car was thrown out at the rate of 700 metres a second by an explosion of a pyroxiline cartridge from the detached head part of the rocket. This took only 0.2 of a second. Now the dog had to stand a sixfold overcharge.

At a height of 35-50 kilometres when the velocity of the fall reached 1000-1150 metres a second a similar explosion threw out the dog in the left car. The animal's parachute opened when it reached a distance of 4000 metres from the earth. In order to prevent suffocation flaps were made in the togs which opened automatically at a height of less than 4000 metres. Twelve dogs participated in the flights at the second stage of the work. During the tests none of the dogs perished due to oxygen deficiency, meteorite radiation or any other factors acting in the upper layers of the atmosphere.

"Today we may state with assurance," said Academician Blagonravov, "that the first step to man's flight in a rocket has been already made. We are on the threshold of the realization of Konstantin Tsiolkovsky's wonderful idea about interplanetary communications. I will say more, the level of modern technique has already made it possible to build a rocket for a flight to the moon.

"A comparison of the results of our researches with those conducted in other countries to study cosmic space shows that our country not only does not lag behind in this field but has in some respects taken the lead.

"There can be no doubt that very soon we shall send the animals to a still greater height and thus make a new leap into cosmic space," concluded Academician Blagonravov.

However, Soviet scientists were interested not only in physiological experiments. They tried to make as much use as possible of every flight of a rocket. What other problems were solved in these flights? This question can be best answered by

the physicists S. M. Poloskov and B. A. Mirtov who made a very interesting report about the studies of the upper layers of the atmosphere with the help of rockets at a conference recently held in Paris.

"When a rocket moves, it is surrounded by a cloud of gases. The great speed of the rocket and this cloud make it difficult to study the atmosphere in its pure state," said the scientists.

In order to avoid errors special mortars were attached to both sides of the rocket. Their tops were covered with cowls. At a definite height the mortars "shut out" an original container —a projectile two metres long and forty centimetres in diameter. In it were measuring devices, storage batteries, milli- and micro-ammeters, a camera with an armoured plate-holder, a programme mechanism, a watch and a motor which sets going the camera and all the automatic devices in the container. All these apparatuses were tightly shut in the lower part of the projectile and the upper part contained the manometers and 500-3000 cubic centimetre cylinders. But the atmosphere at this altitude being extremely rarefied only a small amount of molecules of the surrounding gases managed to enter into the cylinders. Spectral analysis was to be made of the gas. It had to be done as quickly as possible because the composition of a gas even in a sealed glass vessel changes after several hours on earth. The vacuum in the cylinders is so great that the glass cannot stand normal pressure and the air molecules little by little penetrate through the intact walls.

The ejected container falls like a stone to a height of 10-12 kilometres and then the parachute opens. The device lands on a goffered cone with special bars which stick into the ground.

Soviet investigators applied an interesting method in order to find out the velocity and the direction of the wind at great altitudes. Instead of the aparatuses the container was filled with five 15-kilogram smokeboxes. The smokeboxes exploded one after the other at definite altitudes. The artificial clouds that appeared at the time of the explosion could be well observed

from the Earth for a long time. They were followed with the help of apparatuses and the picture of the movement of the air in different layers was made clear.

In connection with the International Geophysical Year studies will soon be made of the "atmospheric ocean" at various heights and at various geographical points.

Soviet rockets will reach altitudes of several hundred kilometres making it possible to conduct a comprehensive programme of researches. It was decided to send up rockets regularly in the course of the whole geophysical year, chiefly during the so-called world days and in the days when the processes on the Sun are particularly active. Twenty-five rockets will be sent in the Arctic from Franz-Josef Land, 70 from the central belts of the Soviet Union and 30 from the Antarctic, in the district of Mirny.

With the help of high altitude rockets micrometers will be studied which, as experiments show, leave signs on sensitive and polished plates raised to great heights.

Finally, rocket technique will help find an answer to another interesting question, namely how does the inner life of the Sun influence the upper strata of the atmosphere and what processes take place in "kitchen" which makes the climate and the weather on the whole of the Earth.

Medical Problems of Flight into Space

The creation of the world's first artificial Earth satellite by Soviet scientists is a decisive step in man's conquest of cosmic space. A new era has begun, the era of flight beyond the earth's atmosphere....

A new branch of science is being formed, "astronautic medicine." It comprises a very wide range of problems. On the one hand, it is necessary to study the influence of various, often unfavourable factors of cosmic flight upon the human organism. On the other hand, specialists in the field of "astronautic medicine" in collaboration with designers, must work out means which will provide sufficiently comfortable conditions during flight and maintain the health and human capabilities, while in case of an emergency will save the lives of the space ship's crew.

The data on aviation medicine can help a great deal here. However, some of the problems are entirely new and still insufficiently studied.

After leaving the Earth, the rocket must overcome its pull. While the rocket's engines are working and the speed of flight is increasing, the space ship and its crew will experience the action of acceleration. The physiological effect of overstrain upon the organism has been studied in detail and it has been demonstrated that the majority of healthy persons can, without substantial changes in their capabilities, undergo a 4- to 5-fold overstrain, if the action of the forces involved is directed along the axis of the body (from the head to the feet). In the horizontal position of the body, man's resistance to overstrain increases. Greater acceleration values lead to disorders of the blood circulation and effect the central nervous system.

Special overstrain-resisting suits, training and the choice of a man's pose in the moment of the rocket's rise, will make

it possible to raise the resistance to overstrain up to 12-15-fold. However, these figures refer to comparatively short-timed effects of acceleration. It is, as yet not clear how such accelerations can be tolerated for a longer time, *i.e.* during the period necessary for the space ship to rise, or for its return to Earth.

After the gravitational pull of the Earth has been overcome and the rocket's engines have been switched off, a state of dynamic imponderability is reached.

The question to what extent such unusual conditions can change the functional condition of the organism has been the subject of wide discussion in literature, and a number of authors doubted the possibility of the organism to adapt itself to these conditions. It has been supposed that during prolonged action of imponderability serious disorders of the nervous regulation of the physiological functions may occur, especially of the blood circulation and locomotion.

Basing one's assumptions on theoretical data, it is possible to imagine that the life of the space ship crew will have its physiological and psychological peculiarities, connected with the absence of the force of gravity and considerable limitations of different external and internal (vestibular, proprioceptive etc.) stimulants. All these facts should make researchers look for means whereby to maintain an optimal level of the central nervous system's functional condition of the ship's crew. A prolonged condition of imponderability, will, perhaps, require the creation of special devices which will permit the crew to move about inside the space ship, to take food, water, and so forth.

Even in the upper layers of the atmosphere its pressure is but a millionth part of the pressure at the Earth's surface. Hence, the flight of man can be possible only in a hermetically sealed cabin. At present there are technological possibilities to produce hermetically-sealed cabins in which conditions normal for the life of man can be maintained for a prolonged period by regeneration and conditioning of the air. At the same time it is necessary to take into account the possible damage to the cabin by meteorites.

If the hermetic sealing of the cabin will be destroyed at high altitude, it will inevitably lead to heavy disorders of the human organism and even loss of life, unless necessary safety measures are taken. For this reason, as well as in case of accident, the crew must be furnished with special space suits. The possible effect of cosmic radiation presents a particularly complicated problem. Experimental data on this problem are limited.

A considerable part of all the problems of space flight can be solved, and is being solved by world scientists in laboratory experiments on animals and human beings. However, in the laboratory, no matter how perfect the equipment may be, it is not possible to produce all the conditions of flight on the interplanetary ship. This refers especially to problems of prolonged dynamic imponderability and cosmic radiation. Thus, experiments on animals, sent in rockets beyond the earth's atmosphere, were a necessary step in the man's conquest of the cosmic space.

The development of rocket technique in the USSR made such experiments possible. Soviet scientists have carried out research work on animals, which were sent in rockets to an altitude of 100-210 kilometres, *i.e.* beyond the denser layers of the atmosphere. At this height, after the rocket's engines were switched off, the rocket continued to rise and then dropped with an acceleration of gravity. Thus, during the course of several minutes it was possible to attain a state of dynamic imponderability, which is typical of flight into space.

Experiments were made on dogs which, after the corresponding training, easily tolerated a prolonged stay in hermetically sealed cabins and space-suits. This made it possible to register their respiration, blood pressure and to take electro-cardiographic readings without anaesthesia or fixation. Filming was performed simultaneously with registration of physiological functions. Projection of the film made it possible to see the behaviour of the animals in the unusual conditions.

The problem of saving the animals during the falling of the rocket back to Earth appeared to be quite complicated. It was solved in two ways. In the first case the animals landed

together with the cabin with the help of special parachutes, while in the second, they were catapulted from the rocket on various altitudes of descending trajectory of flight. Following separation from the rocket, the parachutes on which vehicles with dogs wearing space-suits are landed, were automatically brought into action.

Both systems of saving were successfully tested and cases of accidental death of dogs were rare. Their safe return to the laboratory made it possible to study the remote consequences of the flight.

Data on physiological functions of animals during flight demonstrate that the condition of dynamic imponderability had no specific effect on the cardio-vascular system or respiration. The initial rise of arterial blood pressure, increased pulse rate and respiration were, evidently, a vegetative component of orientation reaction to the unusual stimulant. Normalization of these functions was noted after several minutes of flight in condition of imponderability. It is of interest to note that the pulse rate and blood pressure did not rise in anaesthesised dogs in condition of imponderability, but, on the contrary, had a tendency to decrease.

Filming data of animals during flight in the rocket did not reveal any pronounced disturbances in their behaviour. There was no motor excitement or attempts to get rid of the straps. In prolonged observations of the dogs after the flight no derangements were encountered that could be ascribed to the effect of the flight.

Consequently, it may be considered as proved, that short flights above the limits of the atmosphere do not cause substantial disturbances in the physiological function of the animals.

A flight into space engenders a prolonged (many days) stay of man in space. However, there are, as yet, no scientific data concerning the prolonged effect of dynamic imponderability, cosmic radiation and other factors of flight. The successful start of the first artificial Earth satellite opens wide possibilities for carrying out prolonged experiments which do not differ from flights into space.

Space Man

In an interview V. V. Dobronravov, D.Sc. (Phy.-Math.), expressed the following views on the subject :-

"Today we can already speak of Moon-bound flights as something within reach in the not so distant future. Indeed the carrier-rocket imparted to the world's first man-made satellite an orbital velocity of some 8 km. a second. To send a space ship off to the Moon we need a speed of more than 11 km. a second, or but 3 km. more. Then the space ship will fly along an elongated ellipse and, after entering the Moon's sphere of gravitation, will land there following some manoeuvring.

"The whole journey will take not more than five days, at a minimum fuel outlay. It has also been calculated that we can get there faster, because if the space ship travels at a speed of more than 11 km. a second, it will be able to reach the Moon even within 24 hrs. We have such projects too.

"Scientists both here and abroad are also planning to fly to Mars. This is how it is going to be organized. It is thought that ten space ships of 1,700 tons each will be aligned for flight on a flying airfield. From a circular orbit round the Earth they will emerge, following a transition orbit, onto an ellipse and move towards Mars, within the sphere of solar gravitation, without burning any fuel. It will take 256 days to get to Mars. To fly back the space travellers will have to wait on Mars or its artificial satellite until Mars and the Earth will be in a favourable conjunction for a return flight. In all they will have to wait 440 Earth-days. Thus, the entire journey there and back will take 952 days, or nearly three years. Scientists presume this space voyage will already be a reality at the close of this, 20th century. There are also projects for a quicker flight to Mars.

"At the outset, the space ships will fly without a crew and be controlled by radio. Only then will the day of pioneer astronauts arrive.

"There will be special suits to maintain human life in space. These space-suits will have special devices to allow the human organism normally function in space.

"On their flight space travellers will be in a "weightless" condition. So far we still know too little about what they will feel, how the alimentary and blood-circulation processes will proceed and how the brain will function. This is all being given serious study now both here, in the Soviet Union, and abroad. Most scientists believe that in this weightless condition the human organism can be adjusted to a normal life. At any rate, this was true of most people experimented upon. Apparently, this problem will find its solution some time from now.

"The same goes also for the problem of the overstrains of inertia to which the human organism will be subjected during the active sections of the space-ship's flight, *i.e.*, when the ship will greatly accelerate its motion. We know that the human organism can bear up under an extremely limited overstrain of inertia. Therefore, space-ships will have engines to make the take-off with an acceleration the human organism will be able to stand."

Cosmic Flight Problems

Even as late as two years ago the problem of cosmic flights and the building of artificial satellites of the Earth appeared highly fanciful. Only specialists were working on the basis of calculations and experience gained through the employment of several jet techniques, on designs of rockets to fly at an altitude of several hundred kilometres at tremendous speeds, such as are needed to set going a man-made satellite of the Earth.

While serious technical difficulties are encountered in carrying out the projects, still by means of sectional rockets it is quite possible today to attain the required altitudes and speeds.

A sectional rocket is essentially a system of rockets, operating successively. To illustrate, a three-stage rocket is made up of three rockets which at first move together. At the start, the first and main rocket is put into operation. After it has accomplished its function it detaches itself from the rest and at that very moment the second rocket goes into operation; when the latter has accomplished its function it too is detached, and the third and last rocket begins to operate. As a result, it becomes possible to shoot up to the required altitude at the needed speed a special body—a satellite of the Earth—equipped with instruments for scientific investigation and for communication with the Earth.

It should be borne in mind that in the solution of this problem substantial difficulties have arisen with respect to the precision and dependability of the apparatus. It is enough to point out that at a speed in the neighbourhood of 8,000 metres a second an error within a few score metres a second in the development of speed, or in the angle of the slope, that is, an error of one or two degrees in the required direction of the movement of the rocket towards the horizon, may lead to a drop of more

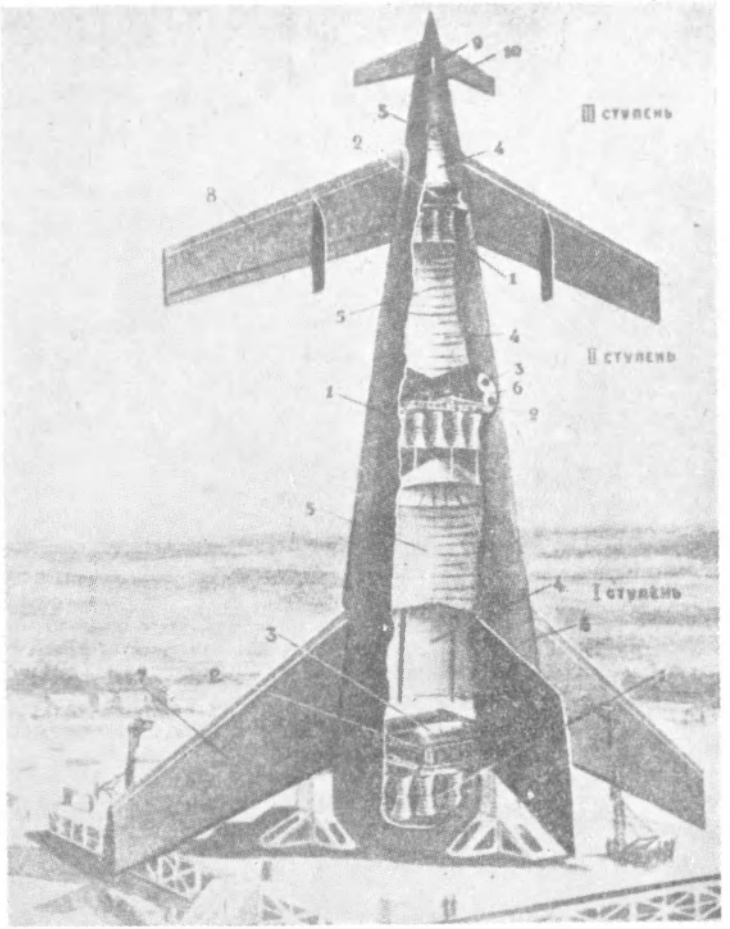
than 100 kilometres from the rated altitude in another spot of the orbit. If the speed or direction is not right, the Earth's satellite may not come out on the required orbit and drop into a denser atmosphere, where it will burn up like a meteor.

It is necessary to solve a number of highly complex problems to make it possible to conduct investigations on the satellite, transmit the results of the measurements to the Earth and maintain regular radio communication with the satellite. A basic requirement for conducting the experiments is small overall dimensions and small weight of all of the instruments and apparatus.

The problem of cutting down the weight of the body and equipment is a major problem in aviation, in which important progress has been made. In aviation we have what might be called "weight cultivation", which has favourably influenced other fields of engineering. For cosmic rockets and for artificial satellites, however, the problem of weight is especially acute and is raised anew. Each kilogram of weight of the satellite requires several hundred kilograms of weight of the auxiliary constructions, of the fuel and of the oxidising agent.

To build cosmic rockets, radically new technical solutions are needed, solutions based on the application of the latest achievements of science and engineering with employment of semi conductors in radio instruments, remote control apparatus and in the exact automatic devices. Special automatic apparatus is required for research, among them special Geiger counters for studying the properties of cosmic rays, and photon counters for picking up the sun's ultraviolet rays. Special apparatus is needed to investigate the Earth's magnetic field and recorders are required to show the temperature and pressure in the satellite, and many other instruments.

In order to be able to maintain radio communication with the satellite for a considerable time and make sure that its instruments work a considerable reserve of energy has to be stored on it. This makes it necessary to set up light sources of energy of large capacitance.



A design of a freight rocket-ferry for two-way communications between the Earth and the artificial satellite. Its three sections have identical parts and an identical design: liquid fuel rocket engine (1); *turbopumps for supplying fuels* (2); *tanks with hydrogen peroxide* (3) *for operating the turbopumps; fuel tanks* (4); *tanks for the oxidizing agents* (5); *the first and the second parts are equipped with landing parachutes* (6); *the first part has a stabiliser for steering in the atmosphere* (7); *the third part has wings and a rudder for landing on Earth when returning* (8); *the pilot's cabin* (9) *is near the passenger cabins and the baggage compartments* (10).

The pay-load of this rocket is 25 *tons.*

A gigantic Cosmic ship to carry the first space travellers to the borders of the Solar system

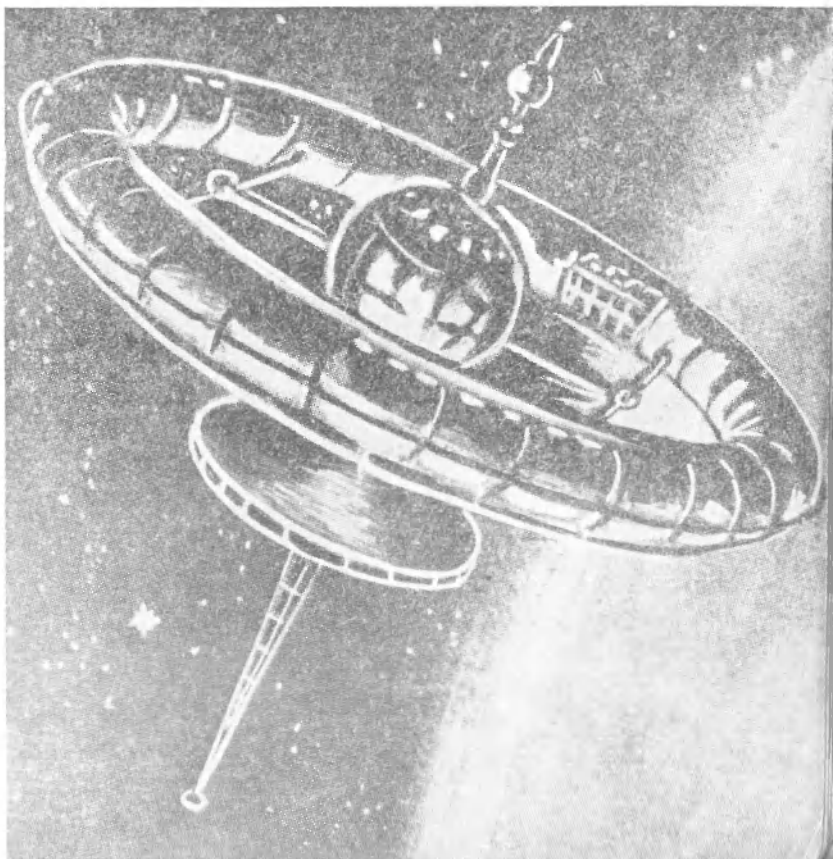
The problem of new sources of energy is very important for the future development of the technique of cosmic flights. It is necessary to continue the many investigations in this sphere.

Of great importance too is observation of the satellite, which will make a complete revolution in its *trajectory* in space in approximately an hour and a half. Because of the Earth's rotation it will be possible to observe the satellite's motion from the most diverse points on the Earth's surface.

Only at altitudes of over 200 kilometres will satellites have a long lifetime. The denser strata of the air at altitudes ranging between 80 and 150 kilometres may rapidly retard the movement of the body. However, this range of altitudes is also of great interest for scientific investigations.

Today there are already designs of flying machines for those altitudes. They are the satelloids, which are an intermediary link between the ordinary rocket and a satellite. In contrast to the satellite, which following its set-off (if we leave out of account the resistance of the atmosphere) moves entirely in conformity with the laws of celestial mechanics, without any other tractive power, a satelloid has to be equipped with an engine the tractive power of which will regulate the ascent or descent of the apparatus. Calculations have shown that a small

The artificial satellite of the Earth



stock of fuel will be needed to keep the satelloid moving at altitudes of approximately 100 kilometres.

After losing some of their speed due to air resistance as they move in their orbit, the first satellites will drop into the dense strata of the air where they will burn up owing to aerodynamic heat. In view of this we can at the present time count on getting from the satellite only such information as can be transmitted by radio, which will yield far from complete data. Scientists are now making attempts to solve the problem of having the satellite return to the Earth from its orbit. This question has already become fundamental in projecting flights of human beings on the satellite and in general for future cosmic flights on vessels manned by crews.

There is little probability of the satellite colliding with meteors large enough to be dangerous. However, there still remains the danger of the effect of cosmic rays on living organisms staying long above the Earth's atmosphere and in interplanetary space. The heavy stratum of air in the atmosphere reliably protects us against their harmful effect.

In programmes for the near future much attention should be given to studying the effect of cosmic rays on living organism in cosmic flights. Along with this it is necessary to study thoroughly a whole series of data of air medicine to learn what effect the setting off the cosmic rockets and long flights in them will have on human beings. Among other things, it should be borne in mind that all objects on the satellite will be weightless. Designs have now been submitted for artificial satellite in which gravitation is produced artificially.

Recent years have witnessed intensive investigations of the upper strata of the atmosphere by means of rockets, in particular rockets with dogs, which parachuted down safely to the Earth. Such investigations have their shortcomings due to the fact that the rockets stay up at high altitudes for a very brief time.

Solution of the problem of building an artificial satellite

of the Earth to serve as an automatic laboratory over a long period is the first stage for interplanetary flights.

The great Russian scientist K. E. Tsiolkovsky described in one of his early works, "Investigation of World Space by Means of Reactive Instruments", the wide possibilities offered by rockets and their special significance to enable man to get beyond the atmosphere. However, the use of rockets for this purpose required a much higher development of engineering than there had been at that time.

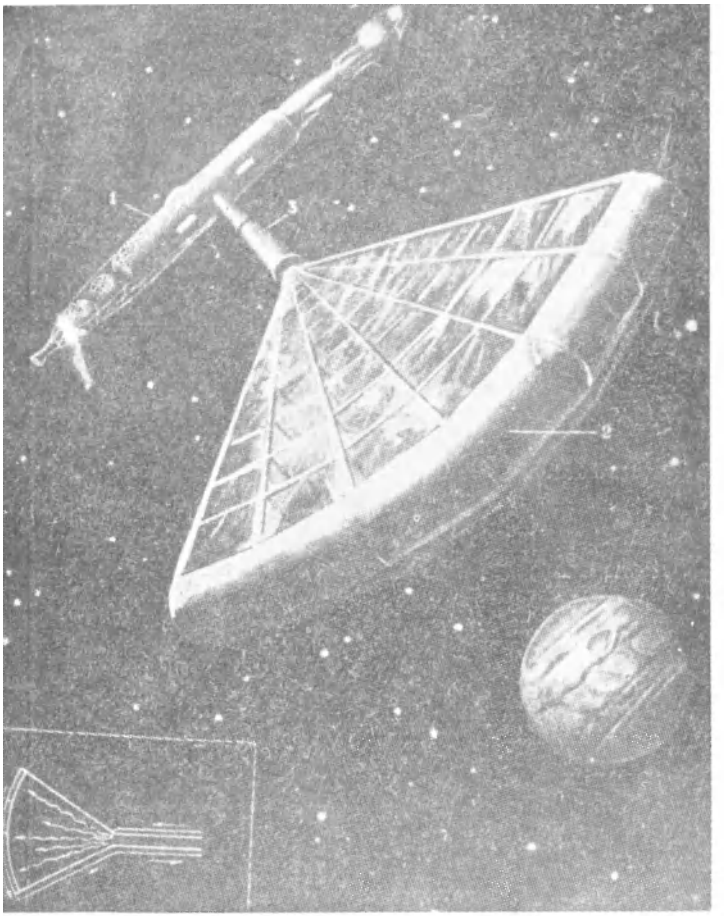
Many scientific works today are devoted to more remote plans of investigations in space near the Sun. Estimates are being worked on the possibility of a flight of a vessel manned by a crew, and calculations are being made of more favourable trajectories for a flight and landing on the Moon, a flight to Mars and other planets. Such calculations are useful already today.

Calculations have shown that a flight to the Moon, landing there and return to the Earth, the present stage of rocket engineering being what it is, would require sending up from the Earth a rocket train weighing several million tons. Because the idea of building such a train is so fantastic, an idea has developed of setting up an intermediate station on an artificial satellite of the Earth. A flight from such an intermediate station and return to it would require a more admissible starting weight of the rocket train.

After it has become possible to fly safely to the upper strata of the atmosphere by means of satellites it will be possible to make a flight to the Moon.

There are plans afoot for flying around the Moon without landing on it. Such flights are more realistic and apparently will be accomplished in the next few years.

The development of science and engineering coupled with the power of Soviet industry is an earnest of success in realising mankind's old dream of investigating interplanetary space.



A cosmic ship (1) *to be used for long distance flights is actually a small artificial planet on which a complete cycle of all matter exchange is performed. A hot house* (2) *serves for the regeneration of the air and the food stocks. Tunnels* (3) *connect it with the ship's main premises. The entire system revolves around a general centre of gravity, thus creating artificial gravity both in the ship's living quarters and the hot house. While revolving it constantly has the transparent wall of the hothouse perpendicular to the rays of the Sun.*

Below is a chart showing the movement of water feeding in the hothouse.

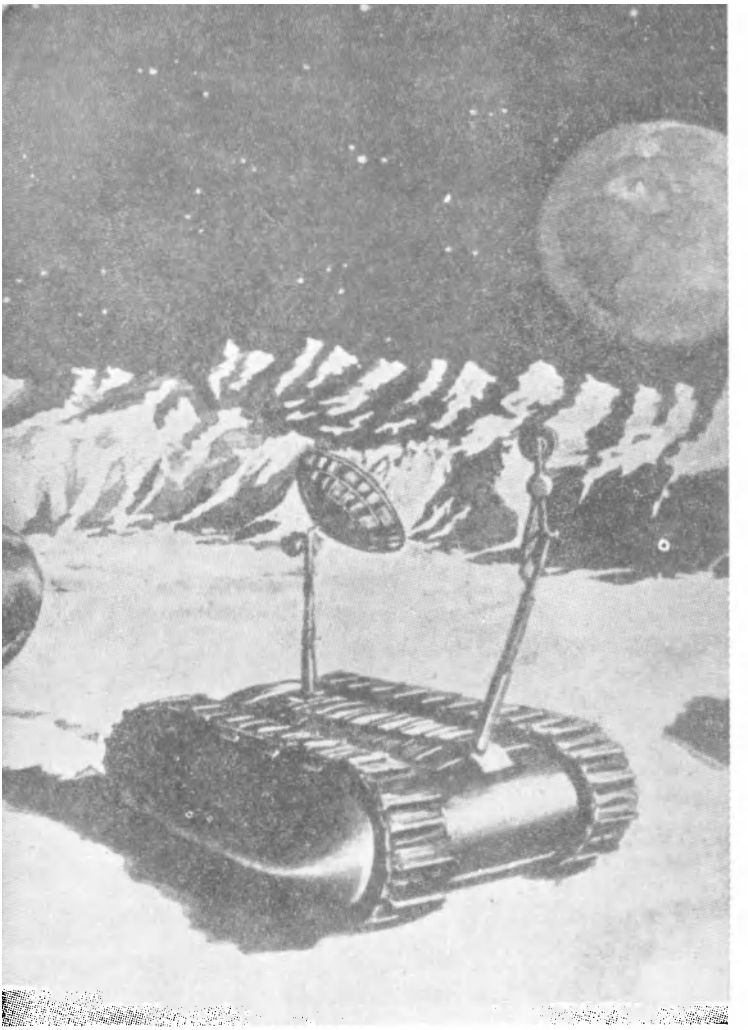
Rocket to the Moon

Speaking of radio-controlled cosmic rockets at the astronautical section of the V.P. Chkalov Central Air Club some years ago, the Soviet scientist Y. S. Khlebtsevich broached a project to send a radio-controlled rocket to the Moon. When landed on the moon, it would release a small laboratory similarly controlled by radio from the Earth. The laboratory in turn would be fitted with a television transmitter and highly sensitive precision instruments to tell us all we need to know about the Moon's atmosphere and surface.

The American magazine "Mechanics Illustrated" recently carried an article by one Pier J. Hass who was troubled because most of the American rocket specialists proposed first to create a grand artificial satellite operated by a crew of men, and only then, after having erected gigantic interplanetary ships, to send the scientists on their first expedition to the moon. This would take the United States at least thirty years. The expenses, moreover, would be staggering. According to Y. S. Khlebtsevich's project, on the other hand, the flight to the moon could be carried out much sooner and considerably cheaper.

Hass was very anxious. What if the USSR sent a cosmic ship to the Moon sooner than the USA; what if Soviet Russia captured this nearest of the planets and took possession in accordance with international law effective on Earth—just as it would a new island? "The Russians," wrote Has, "would inflict us a heavy blow if they captured the Moon. The risk of America's loss of ascendency in outer space and also in the matter of reaching the Moon is very real. Why shouldn't we make a great effort now to hoist the flag of the USA on the Moon?" (Translated from the Russian.)

The author then hurriedly went on to convince the readers of his magazine that the time had come for the USA to declare its rights on the Moon, "to secure the interests of the future generations of free mankind. If we don't, the Russians will out-

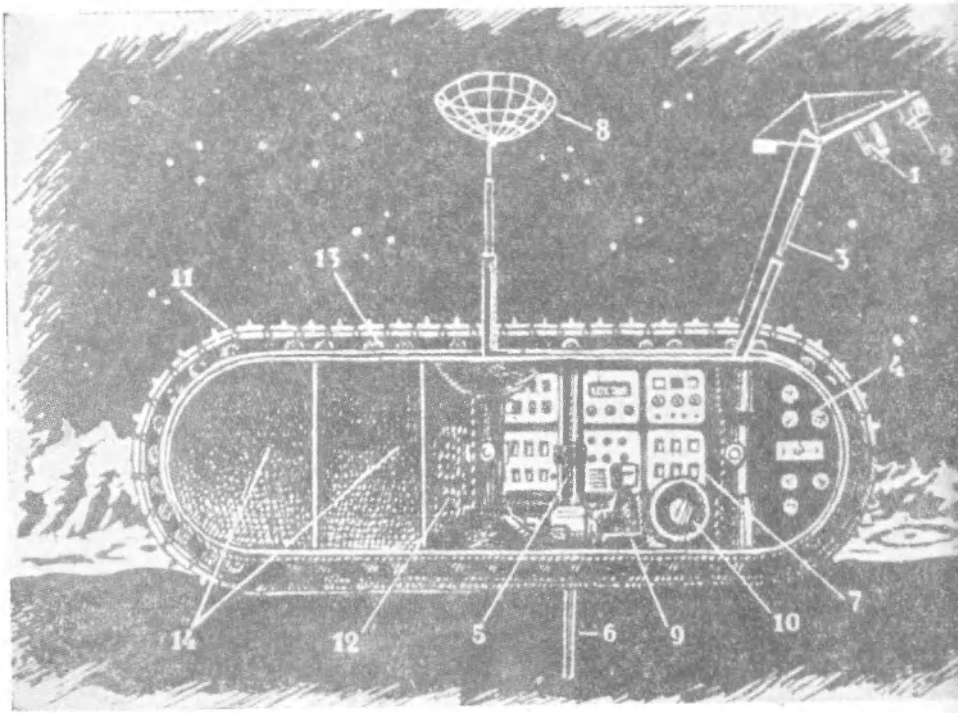


Leaving the rocket's dented body of landing the automatic tank disturbs the age-old dust of the Moon with its caterpillar tracks

strip us: first they'll capture the Moon and then submit their conditions." (Translated from the Russian.)

Questioned about this by a reporter of the "Trud", Y. S. Khlebtsevich expressed the following views:

"The flight to the Moon could become a fact in the next



The interior of the automatic tank: A tele-radio receiver (1) *and a searchlight* (2) *on a special folding stand* (3) *are its "eyes". Diverse instruments* (4) *occupying the front part of the tank are its "organs of perception". A special device* (5) *with a bit* (6) *serves for taking samples of the soil. Radio-tele-transmitting apparatus and wireless receivers* (7) *are mounted in the centre of the tank and are fitted with a collapsible antenna* (8); *an internal combustion engine* (9) *and electric motors* (10) *serve as the driving force for the tank's caterpillars.*

Batteries (12) *serve as an additional source for fuelling these motors and the instruments. They are recharged by the thermoelectric generators* (13). *The fuel tanks* (14) *contain fuel and an oxidizing agent for internal combustion engine.*

five or ten years. The possibility of such a flight is supported by sound scientific facts. A particularly important role in this will devolve on the radio control of cosmic rockets, youngest sphere of technics. The feasibility of the venture rests on the latest achievements in radio technics, radio location, automatics, telemechanics, electronics, television, the science of transistors and, finally, in numerous branches of electro-technics.

"This new sphere of technics will enable us to dispatch the first cosmic rockets without crews and therefore without waiting for the final solution of the problem of man's survival under new conditions. The start, the flight, manoeuvres and landing of the rocket will be implemented and controlled by radio-tele-apparatus on Earth and aboard the missile.

"Directed from the Earth, the rocket would in turn 'land' a mobile laboratory on the Moon; it would be mounted on caterpillars like a small tank and likewise be controlled by radio from the Earth. The tank would be fitted with a television set which would enable the scientists to inspect and photograph the surface of the Moon, the lunar sky with its view of the Earth's disc and, finally, to map out the safest routes for the travelling laboratory.

"The television broadcasts from the Moon will resemble the usual out-of-studio television broadcasts. Millions of T.V. owners on earth will be able to watch these broadcasts as they would any other. The short range of the usual television broadcasts is due to the fact that ultra short waves cannot bend about the Earth. A broadcast from the Moon, on the other hand, is quite feasible through the usual television stations by means of special apparatus to be designed by ourselves.

"The construction of the cosmic rocket would be considerably simplified, since a small tank would not require those special conditions without which a crew of men could not do. Its fixtures will endure far greater acceleration, changes of temperatures and air pressure than man can endure. Nor is there any need to provide for the protection of the rocket and its tank from meteorites. And finally, the tank and the rocket could both

be left on the Moon without troubling about their return to Earth. The trip of the rocket, therefore, would be cut by one half. This would drastically reduce the required quantity of thermo-chemical fuel. Whereas the flight of an interplanetary ship with a crew of men along the route Earth-Moon-Earth would according to the projects of the "rocketeers" require some millions of tons of rocket constructions and fuel besides the establishment of a huge new satellite of the Earth, the one-way transportation of a small laboratory tank to the Moon would demand only 250 tons.

"How is the radio rocket to be controlled? The trajectory and schedule of its flight will be 'plotted' by a special electronic computing machine. After its start, the rocket will be "watched" by several autamatic radio location stations. Collaborating with the apparatus aboard the missile, they will determine its position and path with great precision. Their findings will pass on to the computing machine which, in the event of deviations on the part of the rocket, will promptly determine the radio correction commands. The refuelling of the rocket may be accomplished at intervals by means of automatic and likewise radio controlled refuellers.

"After its successful landing, the laboratory tank could help the scientists to choose the most convenient place on the Moon for the landing of rockets carrying human crews and passengers. Fuel, special equipment, water, air and food could then be carried to the Moon by other radio controlled rockets. They could land at appointed places signalled by the radio station of the tank laboratory which could serve as a beacon. This phase of the operations would be far too cheaper than the American projects.

"The mastery of the Moon with the aid of radio rockets and tank laboratories," concluded Y. S. Khlebtsevich, "will meet with no fundamental difficulties in the technics of rockets and remote radio control.

"As for the article of Mr. Pier J. Hass and his appeal: 'Let

us proclaim our rights on the Moon right now!' we are somewhat at a loss to understand it. The Soviet scientists are not at all out to erect military bases on the Moon from which to menace the United States. Our efforts in astronautics are directed towards learning the secrets of cosmic space as soon as possible, the better and more thoroughly to perceive the limitless universe. In this we could, of course, unite our work with that of scientists in the United States and other countries."

MANNED SPACE FLIGHTS

	Spacecraft	Nation	Date	Astronauts	No. of Orbits	Flight Time (hours & minutes)
1.	Vostok 1	USSR	April 12, 1961	Gagarin	1	1.48
2.	Freedom 7	US	May 5, 1961	Shepard	sub-orbital	:15
3.	Liberty Bell 7	US	July 21, 1961	Grissom	sub-orbital	:16
4.	Vostok 2	USSR	August 6-7, 1961	Titov	17	25:18
5.	Friendship 7	US	Feb. 20, 1962	Glenn	3	4:55
6.	Aurora 7	US	May 24, 1962	Carpenter	3	4:56
7.	Vostok 3	USSR	Aug. 11-15, 1962	Nikolayev	64	94:22
8.	Vostok 4	USSR	Aug. 12 - 15, 1962	Popovich	48	70:57
9.	Sigma 7	US	Oct. 3, 1962	Schirra	6	9:13
10.	Faith 7	US	May 15-16, 1963	Cooper	22	34:20
11.	Vostok 5	USSR	June 14-19, 1963	Bykovsky	81	119:06
12.	Vostok 6	USSR	June 16-19, 1963	Tereshkova	48	70:50
13.	Voshkod 1	USSR	Oct. 12-13, 1964	Feoktistov Komarov Yegorov	16	24:17
14.	Voshkod 2	USSR	Mar. 18-19, 1965	Belyayev Leonov	17	26:02
15.	Gemini 3	US	Mar. 23, 1965	Grissom Young	3	4:53
16.	Gemini 4	US	June 3-7, 1965	McDivitt White	62	97:48
17.	Gemini 5	US	Aug. 21-29, 1965	Cooper Conrad	120	190:56
18.	Gemini 7	US	Dec. 4-18, 1965	Borman Lovell	206	330:35
19.	Gemini 6	US	Dec. 15-16, 1965	Schirra Stafford	16	25:52
20.	Gemini 8	US	March 16, 1966	Armstrong Scott	7½	10:42
21.	Gemini 9	US	June 3-6, 1966	Stafford Cernan	48	72:22
22.	Gemini 10	US	July 18-21, 1966	Young Collins	46	70:47

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